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SETTLEMENT REMEDIAL ACTION PLAN
PREPARED IN RESPONSE TO THE SEPTEMBER 1987 RECORD OF DECISION FOR THE ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION (ECC) SITE
ZIONSVILLE, INDIANA

SEPTEMBER 26, 1988

PREPARED FOR:

ECC SETTLERS STEERING COMMITTEE

PREPARED BY:

ENVIRONMENTAL RESOURCES MANAGEMENT-NORTH CENTRAL, INC.
102 WILMOT ROAD, SUITE 300
DEERFIELD, ILLINOIS 60015

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SEPTEMBER 1987 RECORD OF DECISION
FOR THE
ENVIRONMENTAL CONSERVATION AND CHEMICAL CORPORATION (ECC)
SITE
ZIONSVILLE, INDIANA

BACKGROUND

To facilitate settlement and without waiver of any rights, Environmental Resources Management - North Central, Inc. (ERM) was retained by the ECC Settlers Steering Committee to prepare a Remedial Action Plan for the ECC site which meets the requirements of the plan described by the EPA in the September 1987 Record of Decision (ROD). The alternative remedial action plan presented herein (the Settlement Plan) addresses each of the environmental concerns associated with the ECC site, is cost effective, remediates observed contamination at the ECC Site in a complete and timely fashion, and most closely complies with SARA requirements since it involves on-site destruction of contamination.

EPA'S REMEDIAL ACTION PLAN (THE EPA PLAN)

The major components of the EPA Plan include:

- o Access control and monitoring,
- o A RCRA Performance Cap,
- o Ground water interception and collection,

LAW OFFICES

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September 28, 1988

151818

BY HAND

Ms. Elizabeth Maxwell
Associate Regional Counsel
U.S. EPA - Region V
111 West Jackson
Third Floor
Chicago, IL 60604

Re: Environ Chem Settlement Offer

Dear Ms. Maxwell:

It was our intention in the September 1, 1988 settlement proposal to include all of the basic components of our March 23, 1988 preliminary proposal. The September 1, 1988 letter did not go into the design details. Those details together with the technical support for the proposal are contained in the attached "Settlement Remedial Action Plan" dated September 26, 1988.

We look forward to meeting with you tomorrow.

Very truly yours,

Norman W. Bernstein, for
himself and Tim Harker

NWB8946L

Enclosure

cc: Ms. Karen Vendel

- Ground water treatment with an on-site facility.

The components of the EPA Plan are intended to address the contaminated soil at the ECC Site as well as contaminated ground water in the saturated till beneath the site. The ECC site presently has a surface runoff discharge point at the southern end of the property, which is an overflow from a sump installed by EPA as part of its emergency response actions at the ECC site.

ECC SETTLER'S REMEDIAL ACTION PLAN (THE SETTLEMENT PLAN)

The major components of the Settlement Plan include:

- Access restrictions
- Ground water and surface water monitoring
- Diversion of surface water runoff upgradient of concrete pad
- Collection of contaminated water from beneath the concrete pad
- Shallow, saturated zone ground water interception and collection
- Soil vapor extraction, preconcentration and destruction (carbon adsorption and thermal destruction)
- Soil cover

The primary, active remediation component of the Settlement Plan is soil vapor extraction. The ECC Settlers Steering Committee has solicited opinions from consultants, notably Terra Vac, regarding the suitability of vapor extraction for the ECC site. Terra Vac, a recognized leader in soil vapor extraction and a contractor chosen by the USEPA for vapor extraction remediation, has conducted a pilot-test at the site and the results of that test (Attachments 1 & 2) demonstrate that vapor extraction is a viable and effective alternative for the ECC site. The current estimate is that vapor extraction will be operated for approximately one year to achieve clean-up limits. A more accurate estimate can be provided once residual concentrations, based on risk, have been established.

The ECC Settlers Steering Committee is confident that the settlement response measures listed above will fully address all necessary remedial actions for the ECC site. This proposed plan incorporates, elaborates and expands on the conceptual remedies proposed previously by the ECC Settlers Steering Committee (letter to Ms. Karen Vendl of USEPA from ERM-North Central dated May 19, 1987) and responds to the concerns raised by Mr. Basil Constantelos in his letter of February 10, 1988 to the ECC Technical Committee. Furthermore, the Settlement Plan is the plan that best meets SARA objectives.

This proposed remedial action plan covers remedial action at the ECC site only, however, a significant amount of coordination with the NSL remediation design and construction will be required. Nevertheless, this proposed remedy is fully compatible with the Northside Landfill (NSL) Steering Committee's Proposed Alternative Remedy presented to the EPA on February 12 1988, which we support. The ECC site is physically and chemically distinct from the NSL site, and physically distinct and separate from the new source of contamination (the Finley Creek Source) that was discovered and initially investigated by ERM for the ECC

Settlers Steering Committee. Although chlorinated solvents were detected at the Finley Creek Source, a careful review of aerial photographs and analysis of the available hydrogeological data indicate that the area is physically distinct from the ECC site, that the contamination does not result from the transport of contaminants from the ECC site, and that this contamination is a separate source from the ECC and NSL sites.

DESCRIPTION OF THE SETTLEMENT PLAN

Conceptually, the Settlement Plan consists of 7 components as previously listed. A detailed description of each component is presented below and the components are illustrated on Figures 1 and 2.

1) Access Restrictions

Deed restrictions would be placed on the ECC site. The restrictions should prevent future development of the land to protect against direct contact with contaminants or further migration that could result from site excavation and development. The deed restrictions should also prohibit the use of ground water or installation of wells on-site in both the saturated till and the underlying sand and gravel. The ground water use restrictions would also extend to areas where utilization of the shallow ground water would result in contamination drawn to those locations. Access to the ECC Site would be controlled by fencing around the site perimeter and the posting of signs.

2) Ground Water and Surface Water Monitoring Program

The effectiveness of the Settlement Plan will be assessed through a ground water and surface water monitoring program. Ground water would be monitored at three (3) monitoring wells located downgradient of the southern limit of the ECC property (Figure 1). The wells would be installed in the sand and gravel unit underlying the near surface till. The wells would be sampled quarterly the first year and analyzed for parameters on the Target Compound List (TCL). The sampling frequency and analysis parameters for subsequent sampling will be determined after review of the first year data. Surface water would be sampled at the same frequency at the sampling location shown on Figure 1 and analyzed for the same parameters as the monitoring wells. The duration of ground water and surface water monitoring will be continued beyond the operational period of the active remedial system based on analytical data from the monitoring wells.

3) Diversion of Surface Water Runoff Upgradient of Concrete Pad

Because an interim soil cap has been placed over the site, the only known source of contaminants to surface runoff is the subgrade material beneath the concrete pad on the southern end of the ECC site. According to the RI for the ECC site, surface water runoff from the northern part of the site largely flows south where a berm along the north edge of the concrete pad redirects runoff to a drainage ditch west of the site. This berm will be repaired and/or reinforced to ensure that runoff is diverted and is not able to infiltrate beneath the pad. This will essentially eliminate the generation of contaminated runoff into the EPA-installed sump located at the south end of the pad.

4) Collection of Contaminated Surface Water Beneath the Concrete Pad

As previously noted, surface water which infiltrates the concrete pad may become contaminated. A lined collection trench approximately 4 feet deep by 1 foot in width will be installed along the south and southeast portions of the concrete pad to collect potentially contaminated surface water (Figure 1). The trench will drain to a holding tank. The collected water will be conveyed to the NSL pipeline for conveyance to the Indianapolis sewerage system for final treatment. Once the surface water diversion system described in 3, above, is installed, the amount of water flowing into this trench will be negligible.

5) **Ground Water Interception**

The ground water interception system will consist of a single french drain extending east-west south of the ECC site along the north side of the NSL access road (Figure 1). The drain will be approximately 230 feet in length, 4 feet in width and will extend an average of 10 feet beneath the surface (Figure 1). The purpose of the drain is to collect contaminated ground water, if any, from the glacial till. Using the hydrogeologic assumptions from the ECC Feasibility Study for the design of the french drain system, approximately 0.5 gallons per minute would flow to the drain. This water would be the combined volume of infiltration for the surface, flow through the till, and upward flow for the underlying sand and gravel. This water will be collected in the same holding tank as described in 4. Water collected would be conveyed to the NSL connection to the Indianapolis sewerage system for final treatment.

6) **Soil Vapor Extraction Preconcentration and Destruction (Carbon Adsorption and Thermal Destruction)**

A conceptual design and preliminary cost estimate memorandum is included as Attachment 3.

7) **Soil Cover**

A soil cover, using the highly impermeable native till, will be installed and compacted over the ECC site to prevent erosion and water ponding on-site. Prior to placing the till, the site would be graded, to fill existing depressions, eliminate sharp grade changes and provide for site drainage. Vegetative cover will also be established to mitigate potential effects of erosion.

SCHEDULE AND COST

The estimated time required to complete design and implementation phases of the Settlement Plan is illustrated in Figure 3. This schedule is based on the number of weeks for a notice to proceed.

Estimated costs to implement the Settlement Plan are shown on Table 1.

TABLE 1
PRELIMINARY COST ESTIMATES, SETTLEMENT
REMEDIAL ACTION PLAN, ECC SITE

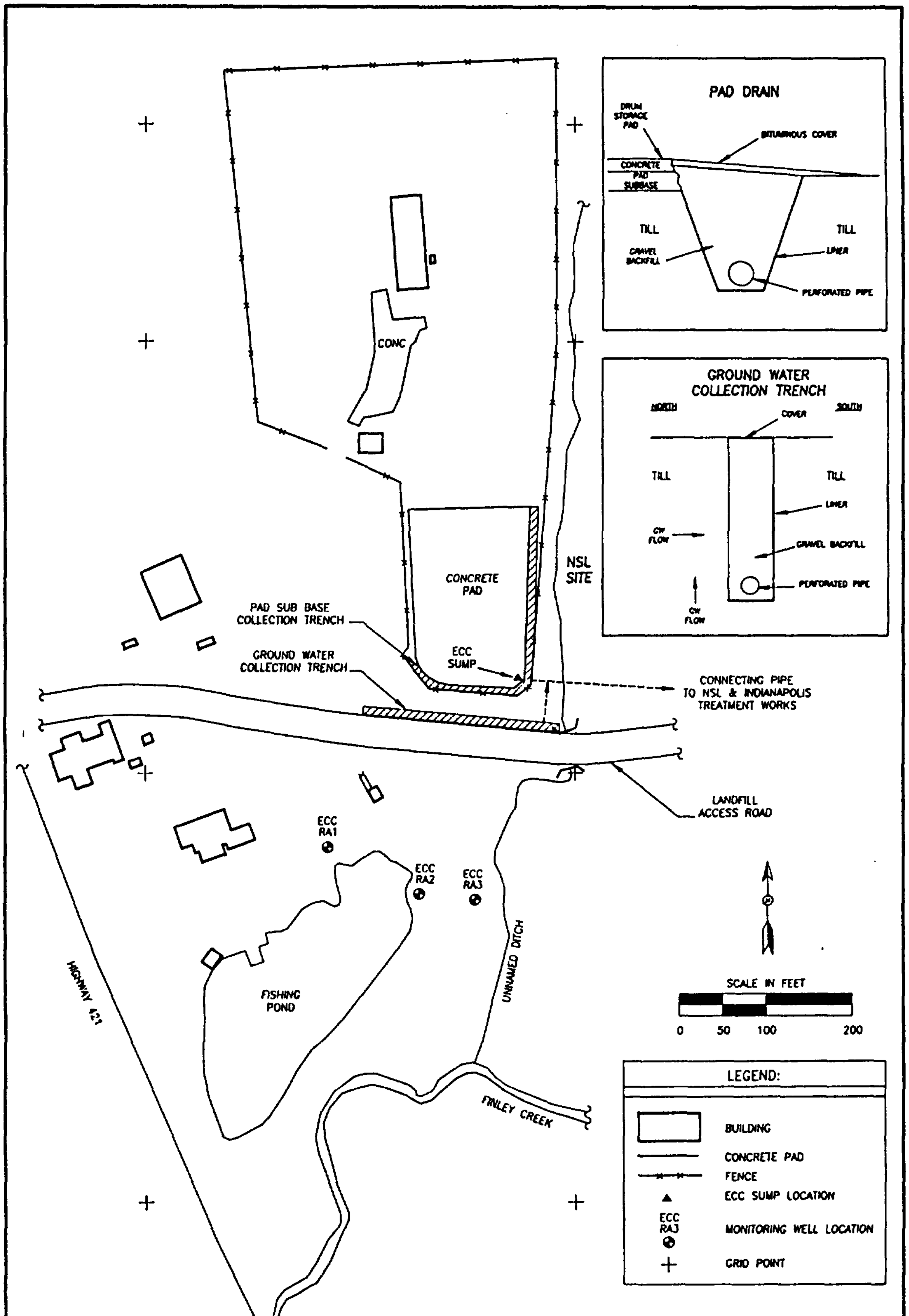
Direct Capital Components	Quantity	Unit	Total
1. Access Restrictions			
- fencing	2,100 LF.	$ 12/LF	$ 25,200
- misc. (Gates, Signs)	---	---	2,500
			27,700
2. Ground Water and Surface Water Monitoring			
- wells	3 EA.	5,000/EA.	$ 15,000
- misc. (Sampling Equipment)	---	---	1,500
			16,500
3. Diversion of Surface Water Runoff Upgradient of Concrete Pad			
- misc. (Berm regrading/buildup etc.)	---	---	$ 10,000
4. Collection of Residual Leachate Beneath the Concrete Pad			
- excavate trench	110 CY	8/CY	$ 880
- line trench (geotextile)	4,000 SF	0.17	680
- perforated pipe	365 LF	6/LF	2,190
- gravel backfill	100 CY	15/CY	1,500
- sump station	1 EA.	2,000/EA.	2,000
- holding tank	1 EA.	2,000/EA.	2,000
			9,250
5. Ground Water Interception			
- excavate trench	500 CY	10/CY	$ 5,000
- liner, piping, etc.	---	---	4,000
- gravel backfill	500 CY	15/CY	7,500
- wet well, sump pump	---	---	5,000
- holding tank	1 EA.	10,000/EA.	10,000
			31,000

TABLE 1 (cont)
PRELIMINARY COST ESTIMATES, SETTLEMENT
REMEDIAL ACTION PLAN, ECC SITE

Direct Capital Components	Quantity	Unit	Total
6. Soil Vapor Extraction and Treatment			
- site preparation	---	---	$ 20,000
- trench construction	---	---	0
- vapor extraction water piping	3500 L.F.	$ 20/L.F.	70,000
- trench backfill and capping	2000 CU.YD.	$ 20/CU.YD	40,000
- vapor extraction manifold system	300 L.F.	$ 50/L.F.	15,000
- vapor extraction blower, motor, controls	---	---	100,000
- exhaust vapor preconcentration and destruction	---	---	50,000
- exhaust vapor stack and monitoring	---	---	30,000
			325,000
7. Soil Cap			
- clay layer excavation and placement	---	---	185,000
		Sub-Total: Direct Capital Costs:	$ 604,450
		20% Engineer/Design:	121,000
		25% Contingency:	181,000
		TOTAL CAPITAL COSTS:	$ 906,450

Operations and Maintenance Components	Cost for Year 1	Annual Cost Year 2
1. Access Restrictions	$ 5,000	$ 5,000
2. Ground Water and Surface Water Monitoring System	20,000	20,000
3. Diversion of Surface Water Runoff Beneath Concrete Pad	2,000	2,000
4. Collection of Residual Leachate Beneath Concrete Pad	4,000	4,000
5. Ground Water Interception	7,500	7,500
6. Soil Vapor Extraction and Treatment *	868,000	---
7. Soil Cap	10,000	10,000
	$ 916,500	$ 48,500

* Anticipated operation of 1 year for vapor extraction system.



ECC REMEDIAL ACTION: GROUNDWATER COLLECTION TRENCH AND GROUNDWATER MONITORING

FIGURE NO. 1

ERM ERM-North Central, Inc.

9/26/88

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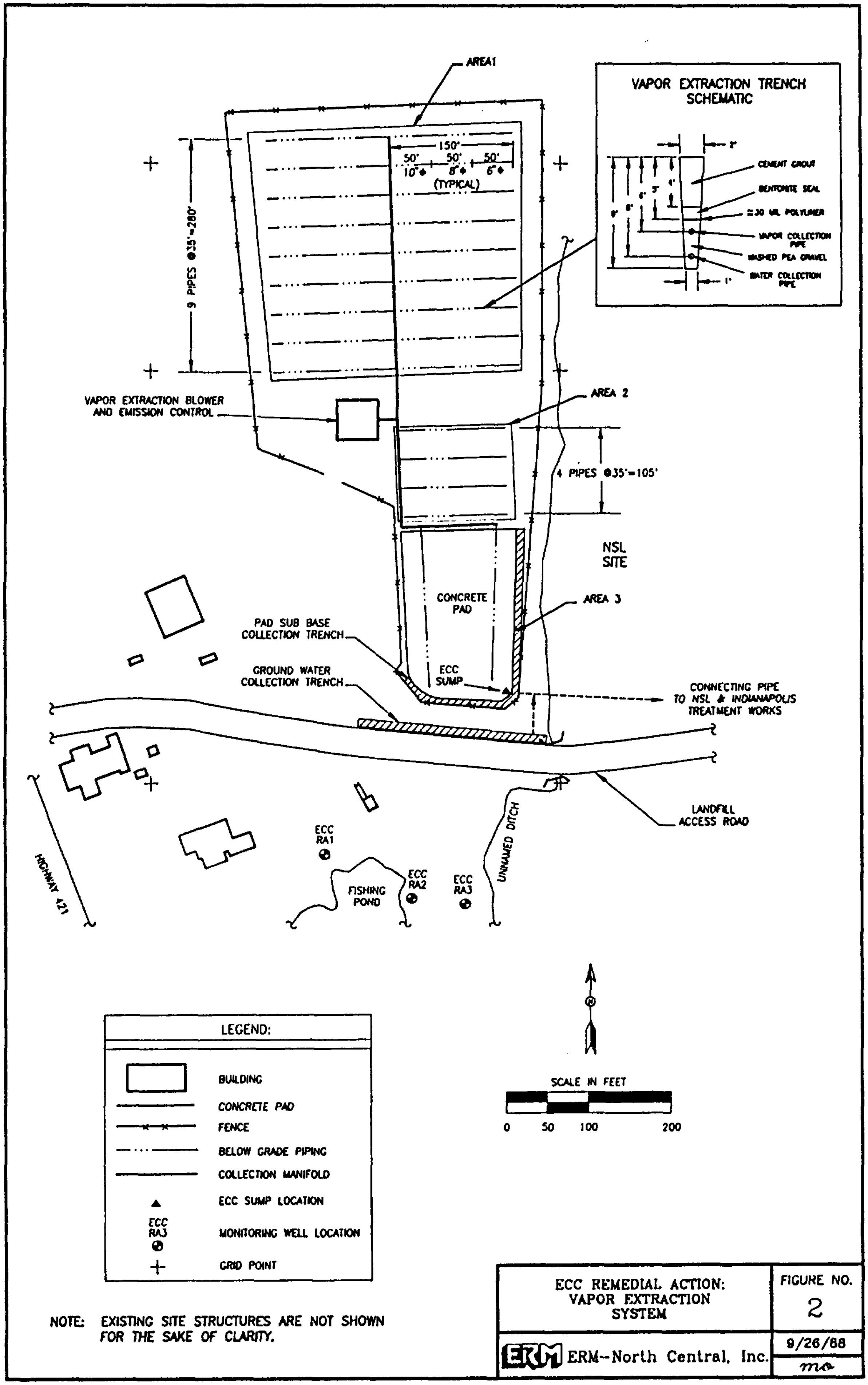
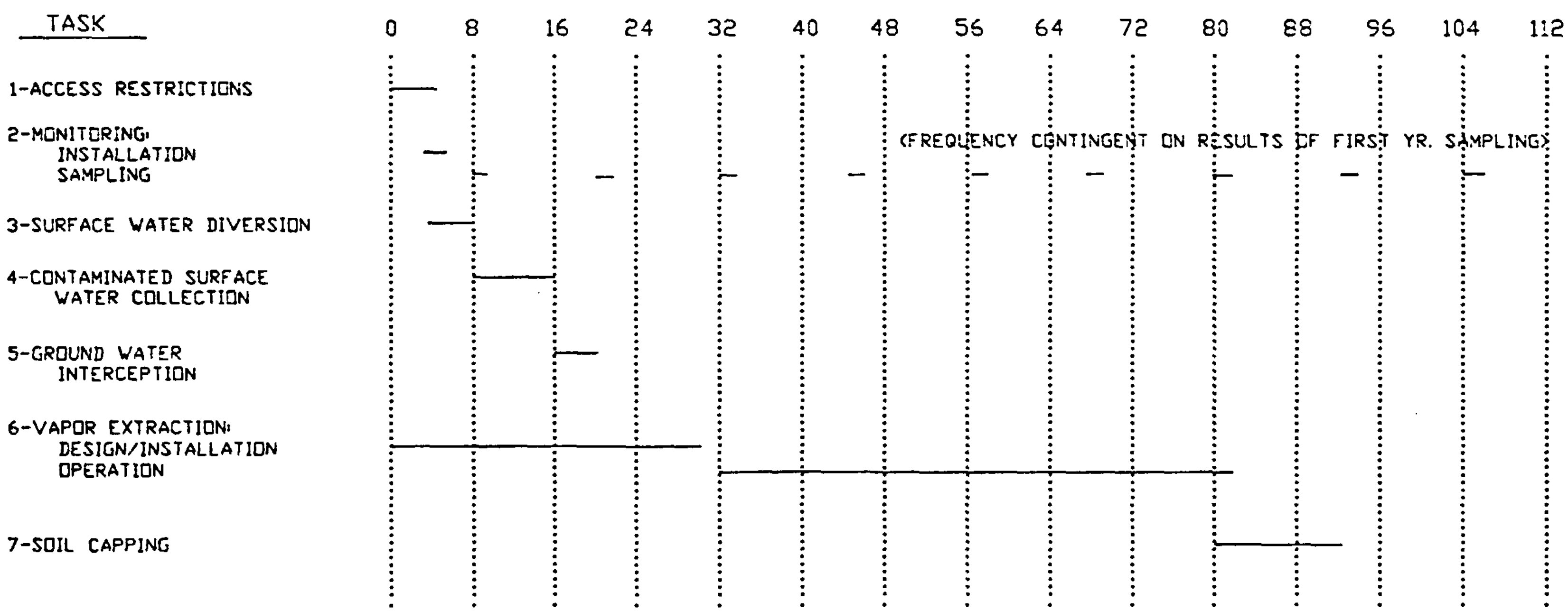


AREA1
VAPOR EXTRACTION TRENCH SCHEMATIC
CEMENT GROUT
BENTONITE SEAL
VAPOR COLLECTION PIPE
WASHED PEA GRAVEL
WATER COLLECTION PIPE
150'
50'
50'
50'
10"Φ
8"Φ
6"Φ
(TYPICAL)
9 PIPES @35'=280'
VAPOR EXTRACTION BLOWER AND EMISSION CONTROL
AREA 2
4 PIPES @35'=105'
NSL SITE
CONCRETE PAD
AREA 3
PAD SUB BASE COLLECTION TRENCH
GROUND WATER COLLECTION TRENCH
ECC SUMP
CONNECTING PIPE TO NSL & INDIANAPOLIS TREATMENT WORKS
LANDFILL ACCESS ROAD
UNNAMED DITCH
HIGHWAY 421
ECC RA1
ECC RA2
ECC RA3
FISHING POND
SCALE IN FEET
0
50
100
200
LEGEND:
BUILDING
CONCRETE PAD
FENCE
BELOW GRADE PIPING
COLLECTION MANIFOLD
ECC SUMP LOCATION
ECC RA3
MONITORING WELL LOCATION
GRID POINT
NOTE: EXISTING SITE STRUCTURES ARE NOT SHOWN FOR THE SAKE OF CLARITY.
ECC REMEDIAL ACTION: VAPOR EXTRACTION SYSTEM
FIGURE NO.
2
9/26/88
ERM
ERM–North Central, Inc.

ESTIMATED PROJECT SCHEDULE
INSTALLATION OF
ECC SETTLEMENT REMEDIAL ACTION PLAN
WEEKS FROM EFFECTIVE DATE OF PLAN APPROVAL



ECC SITE
ESTIMATED PROJECT SCHEDULE
ECC SETTLEMENT PLAN INSTALLATION

FIGURE NO. 3

ERM ERM-North Central, Inc.

8/30/88

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ATTACHMENT 1

INTERIM REPORT
OF
VAPOR EXTRACTION PILOT TEST

JULY 8, 1988

PREPARED BY:

ENVIRONMENTAL RESOURCES MANAGEMENT-NORTH CENTRAL, INC.
102 WILMOT ROAD, SUITE 300
DEERFIELD, IL 60015

INTRODUCTION

Vapor extraction is a process used to remove volatile organics from contaminated soils. The process works by withdrawing volatile contaminants from soil, in-situ. A subsurface vacuum is propagated from extraction wells or an extraction trench which causes vapors to migrate to the extraction wells or trench. The vapors are brought from the wells or trench to the surface where they are vented and destroyed by on-site catalytic incineration (except during the pilot test).

Terra Vac, Inc. is currently conducting a soil vapor extraction pilot test at the Envirochem site (ECC), near Zionsville, IN. Data from the pilot test is to be used to determine the feasibility and the cost of a full-scale vapor extraction system at the site.

INSTALLATION OF THE PILOT TEST VAPOR EXTRACTION SYSTEM

Mobilization of Terra Vac, Inc. to the site began on May 31, 1988. The installation operations of a vapor extraction pilot test system started on June 7. Two 40-foot trenches (HEW 1 and HEW 2, See Figure 1-1) were excavated to a depth of 9 feet. At this depth, a small amount of water (<2 gals) was encountered in the east trench (HEW-1). A dark brown separate phase was noted on the water's surface in de minimus quantity (photograph will be forwarded).

Both trenches were backfilled with pea gravel to the 8-foot level. A four-inch PVC screen was installed along the entire length of each trench. A four-inch PVC riser pipe was connected at each end of the screen and extended above the top of the trench. The trenches were then backfilled with pea gravel to the 5-foot level. A second layer of PVC screen was placed at the 5-

foot depth. The trenches were then backfilled with pea gravel to the 3-foot level. A six-inch layer of wetted-powdered bentonite seal was placed followed by grout to grade level.

The lower pipe (at the 8-foot depth) was installed to collect any ground water that collected in the trench. This lower pipe was not connected to the vapor extraction system. Although no ground water has accumulated since installation (due to drought conditions) we intend to attempt to collect representative samples of ground water for characterization with respect to ultimate discharge to the City of Indianapolis.

The upper pipe is used in the vapor extraction system process. The riser pipe is connected to a pipe at the surface. This pipe leads to the water extraction system, then to the pump where the vapors are vented. Emission controls were not used during the pilot test due to the low emission levels in the vented soil vapors as determined by ambient monitoring.[1]

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[1] Since starting up, the system has been continually monitored by Terra Vac, Inc. using an on-site gas chromatograph. Vapor samples are collected at several points within the flowline and at the exhaust stack. Vapor samples were analyzed approximately every two hours during startup. The sampling frequency was reduced later in the test to approximately once/day. Data from the piezometers were also obtained for use in calculating the zone of influence.

During the system's operation, the site ambient air was monitored by ERM using a Photovac tip. The monitoring points (AM 1-1 through AM 2-9) enclosed the pilot test area as shown in Figure 1-2. Initially, the points were monitored on an hourly basis. Values up to 2.5 ppm above background were noted along the outer circumference. The concentrations measured along the outer circumference were well below the 5 ppm action level confirming that no potential health hazards to neighboring residents existed during the pilot test.

Ten piezometer wells were installed to monitor the system (Figure 1-1). Four of the piezometers (VM-1 to VM-4) were drilled and installed by Engineering and Testing Services, Inc. (ETS) of Indianapolis. ETS also drilled and installed a vertical extraction well (VE-1) which Terra Vac, Inc. intends to use to compare the efficiency of vertical to horizontal collection. The additional six piezometers (KVM-5 to KVM-10) were drilled and installed by Terra Vac, Inc. utilizing a hand drill.

Soil samples were collected during all phases of the trenching and drilling operations. A headspace analysis was performed on each soil sample utilizing an on-site gas chromatograph. Headspace concentrations ranged from 100 - 400 ppm. The main compounds identified included: DCA, DCE, TCE, toluene, PCE, and xylene. During the trenching and drilling operations, the work area was constantly monitored for ambient organic vapors by ERM-North Central personnel, utilizing a Photovac tip. Values obtained did not exceed the 5.0 ppm action level negotiated with IDEM for personnel safety protection upgrading.

PILOT TEST OPERATION

Development of the vapor extraction system started on June 13, 1988. The system has since operated continuously, except during brief shut-down periods for maintenance.

PERFORMANCE ANALYSIS

Based on data provided by Mike Disabato of Terra Vac on June 24, 1988, (a copy of which is attached as Appendix A) ERM-North Central has calculated the performance score of the vapor extraction technology using the results of the pilot test being conducted at ECC. The calculations presented below follow the procedure described in our technical memorandum "Site Specific Evaluation of Vapor Extraction Application"[2] and are based upon data collected through June 17, 1988.

Horizontal Extraction Well No. 2

Trench dimensions: 40 ft long x 1 foot wide x 9 feet deep.

Soil total VOCs concentration: range from 100 to 400 ppm.

Zone of influence: 15 feet (30 feet wide).

Extraction rate at time of development: 57 pounds per day.

Utilizing the above information, the soil mass affected by the vapor extraction pilot test is approximately 40 ft x 30 ft x 9 ft, which equals 400 cubic yards. Assuming 1.5 tons per cubic yard, this equates to 1.2×10^6 pounds of soil. Based on the RI data, 400 ppm was conservatively assumed as the initial VOCs concentration for the entire soil mass. This is equivalent to 480 pounds of VOCs in the affected soil mass. Therefore, with an extraction rate of 57 pounds per day when the trench was developed, the initial contaminant mass extraction rate is 11.9 percent per day.

The vapor extraction technology performance is rated as follows, utilizing Table 2 in the previously referenced "Site Specific Evaluation of Vapor Extraction":

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[2] Letter from ERM to Karen Vendl, USEPA, April 27, 1988

- The zone of influence (weighting factor of 3) receives a score of 60, since the materials excavated are predominantly clays and the zone of influence is 15 feet.

- The initial contaminant mass extraction rate (weighting factor of 2) receives a score of 80, since the removal is greater than 5 percent of the total concentration within the mass contained in the zone of influence.

- Finally, to be conservative, it is assumed that emission controls (weighting factor of 1) will be required during initial remediation, resulting in a score of 60.

These scores are then multiplied by their weighting factors, added, and divided by 6 to calculate an average performance score of 66.67 for Horizontal Extraction Well No. 2. If no emission controls are required during full-scale operation, the resultant performance score would be 70.

Horizontal Extraction Well No. 1

Similar calculations were carried out for Horizontal Extraction Well No. 1 for the same time period. The pertinent data are shown below:

Trench dimensions: 40 ft long x 1 ft wide x 9 ft deep.

Soil total VOCs concentration: ranged from 10 to 20 ppm.

Zone of Influence: 15 feet (30 feet wide).

Extraction rate at the time of development: 15 pounds per day.

Calculated similarly to Horizontal Extraction Well No. 2, 200 ppm was conservatively assumed for this area as the average concentration (based on the RI data). The initial VOC mass within the affected soil is 200 pounds, and the initial contaminant mass extraction rate equals six percent. Therefore, utilizing Table 2 to score the performance of Horizontal Extraction Well No. 1, the zone of influence receives a score of 60, the initial contaminant mass extraction rate receives a score of 80, and the emission controls receive a score of 60 with controls during initial remediation and a score of 80 with no controls. The resultant performance scores are 66.67 and 70, with and without controls, respectively.

Referring to Figure 1 of the previously referenced "Site Specific Evaluation for Vapor Extraction Application," a score of 60 or greater is necessary to implement vapor extraction and to proceed with the preliminary design and engineering. Based on the initial results from the pilot test, the performance of the system exceeds the criteria for a recommendation to the design phase.

VAPOR EXTRACTION PILOT TEST EXTENSION

The pilot test has been extended for an additional 4 weeks, starting July 1, 1988. The pilot test was extended to better define the expected duration of operation of a full-scale soil vapor extraction system and the associated cost.

Samples will be collected by ETS 3 times/wk during the extended test period (a total of 12 additional samples) and sent to Terra Vac for GC analysis. ETS will continue to perform ambient site monitoring during sampling. ERM will visit the site once each week to confirm that the sampling and maintenance duties are being performed by ETS. ERM will also confirm that the vapor emissions remain below the action level. The on-site trailer will remain for the extended test.

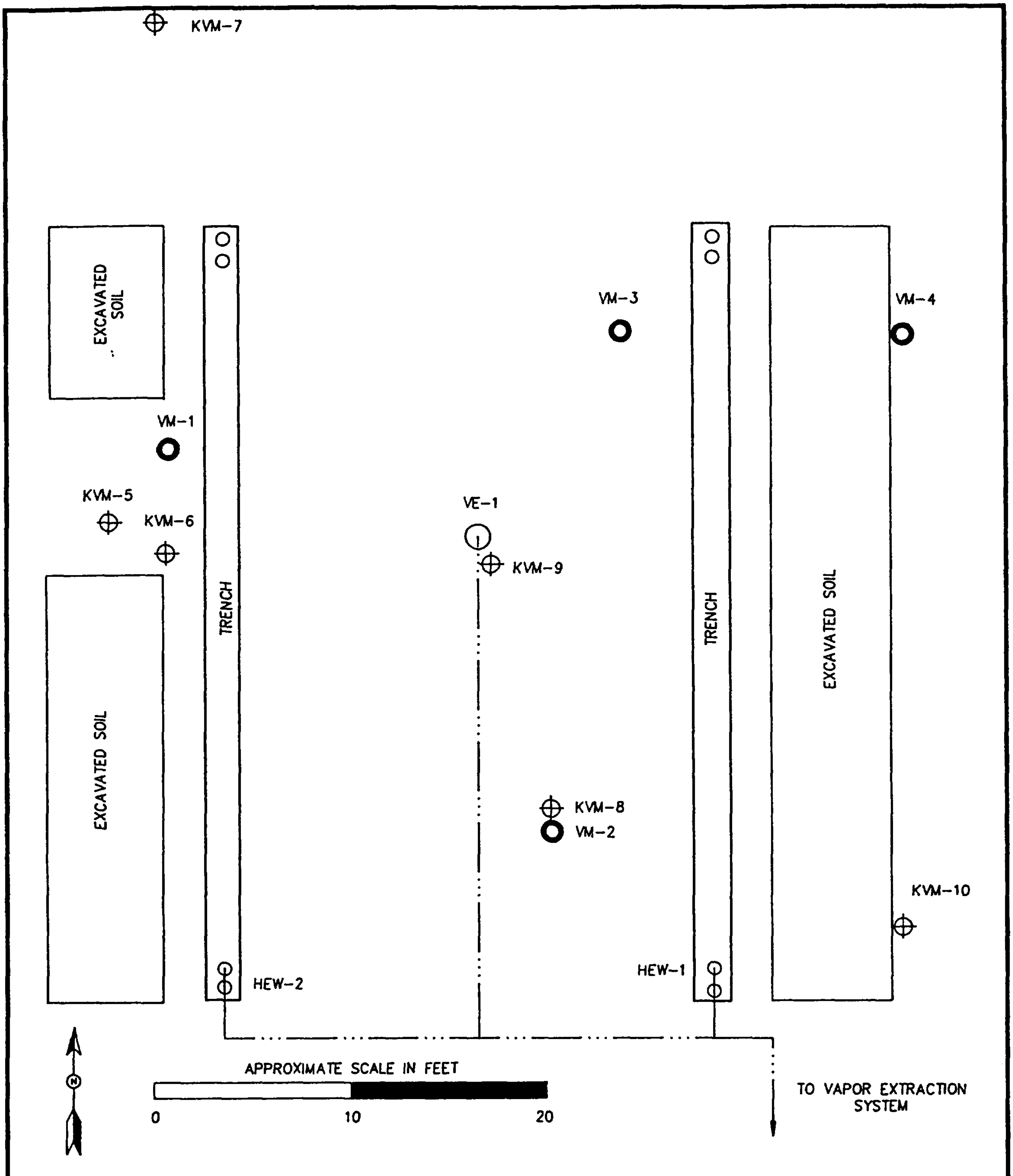
SUMMARY

A vapor extraction pilot test has been conducted by Terra Vac at the ECC site. Based on data received and the criteria previously set, the vapor extraction system is successful in achieving the necessary reduction in VOC concentrations at the ECC site. The pilot test has been extended for an additional four week period. The benefits of the longer test and the associated expanded data base include:

- improved prediction of the zone of influence

- enhanced prediction of the steady-state rate of vapor extraction and soil treatment

- improved design criteria and confidence level for size, duration and cost of operation.

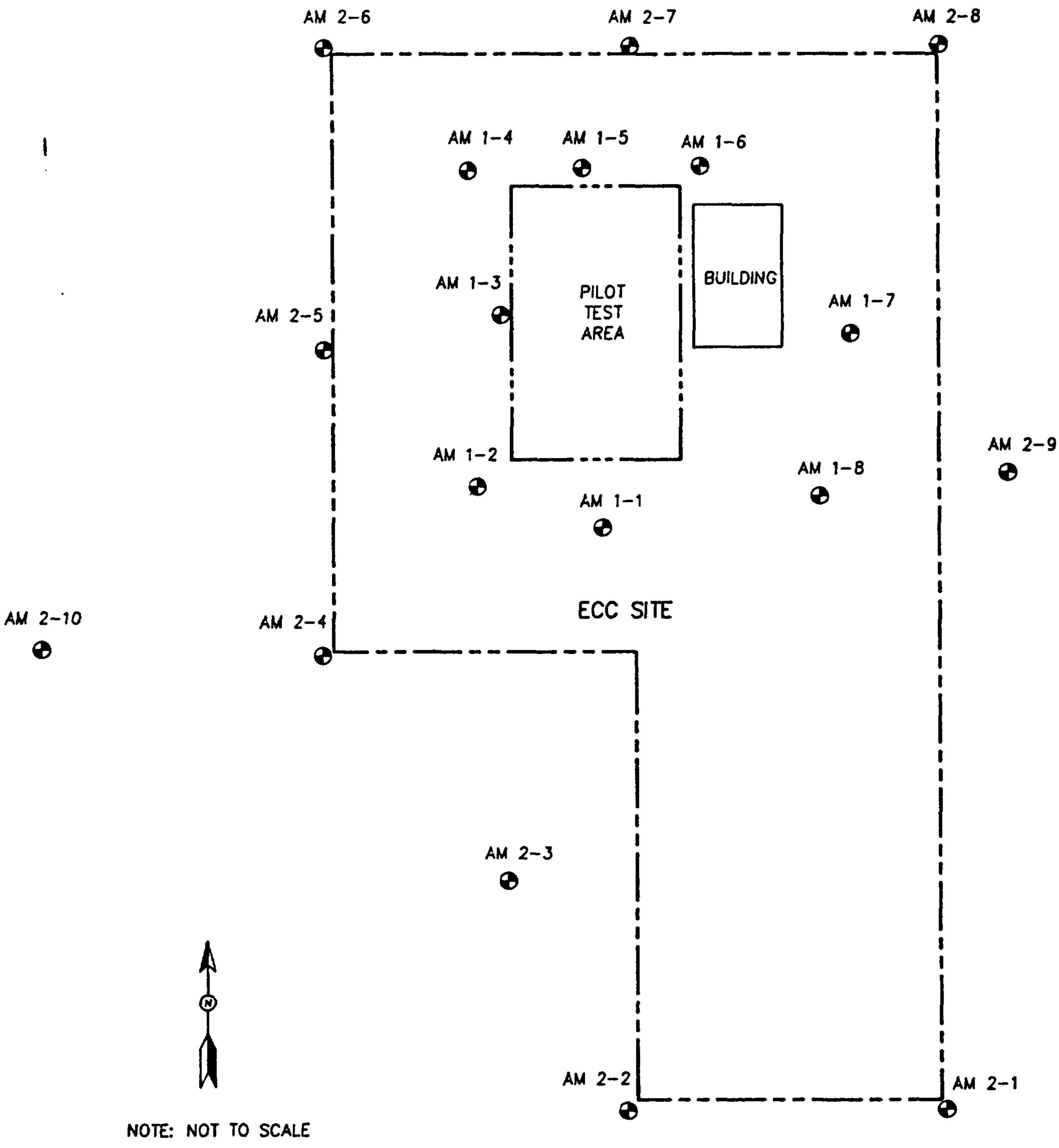


ECC SITE
SOIL VAPOR EXTRACTION SYSTEM
PILOT TEST LAYOUT

FIGURE 1-1

ERM-North Central, Inc.

mo



ECC SITE
AIR MONITORING LOCATIONS

ERM–North Central, Inc.

FIGURE 1–2

APPENDIX A

TERRA VAC DATA

Date: 7/5/88

Deliver to: Paul Kopydlowski

Company: ERM

FAX #: 312-940-9280

From: Tony Dall

Company: TERRA VAC SAN FRANCISCO OFFICE
14204 Doolittle Drive
San Leandro, CA 94577
(415) 351-8900

FAX #: (415) 351-0221

FAX Type: Group III

Total number of pages including this cover letter: 6

Description of Contents: Operations and sample data at ECC site up to & incl 6/27 (preliminary data)

Message: Note: Sample volume and flow changes must be considered ~~that~~ in conjunction with GC readout of concentrations.

* Approximately 300 lbs VOCs removed as of 6/27.

* Daily rates increase with initial development, then start to decline.

* Highest outer perimeter air rdg = 2.5 ppm with wind coming across NSL.
Highest inner perimeter air rdg = 1.5 ppm.

NO WATER

ECC SOILS DATA
TERRA VAC PILOT TEST

4 & VE-1 VM-1.2.3.4 & VE-1 VM-1.2.3.4 & VE-1

	===== SOIL CONCENTRATION (PPM) ========= SOIL CONCENTRATION (PPM) ===								
	DEPT FT.	DCE ppm	TCA ppm	BZ ppm	TCE ppm	TOL ppm	PCE ppm	mp-XYL ppm	TOTAL ppm
-1-3	3.0	.5	2.9	.0	.7	1.0	.0	.1	11.3
M-1-6	6.0	.3	11.8	.0	5.9	.2	.0	.0	18.2
-2-3	3.0	2.2	26.2	.0	74.6	6.2	65.4	1.7	176.4
-2-6	6.0	1.0	14.9	.0	2.3	.5	8.3	.1	27.0
M-3-3	3.0	.0	3.6	.0	.1	.7	.0	.0	4.4
M-3-5	5.0	.4	8.8	.0	10.8	.5	3.1	.0	23.7
M-4-3	3.0	1.6	1.7	.0	.8	.0	.9	.0	5.1
M-4-6	6.0	2.5	17.1	.0	10.7	1.2	2.0	.0	33.5
5-1-3	3.0	2.8	128.5	.0	80.5	5.9	1.5	1.8	220.9
6-1-6	6.0	12.5	90.2	.0	232.5	8.7	47.4	1.9	393.3
6-1-9	9.0	.0	.0	.0	.1	.0	.0	.0	.1

TERRA VAC/ ECC - E

			XX	VE-1					VE-1						
SAMPLE TIME			XX	<< OPERATION DATA >>					<< GAS CHROMATOGRAPH READOUT >>						
			XX		INJ	WELL	FLOW	FLOW	1,1	1,1,1				M,P-	TOTAL
			XX	SAMP	VOL	VAC	RATE	RATE	DCE	TCA	TCE	TOL	PCE	XYL	AREA
DATE	HRS	MIN	XX	NUM	(ul)	("Hg)	(SCFM)	(ACFM)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	1000X
Jun-14	12	17	XX	888											0
Jun-14	12	18	XX	888	100	1.0									0
Jun-14	12	38	XX	888	100	1.0									0
Jun-14	13	18	XX	888	100	1.0									0
Jun-14	13	31	XX	888	100	1.0									0
Jun-14	14	31	XX	888	100	1.0									0
Jun-14	15	31	XX	888	100	1.0									0
Jun-14	15	40	XX	888	100	1.0									0
Jun-14	16	29	XX	888	100	1.0									0
Jun-14	17	29	XX	888	100	1.0									0
Jun-14	20	42	XX	888	100	1.0									0
Jun-15	8	39	XX	888	100	1.0									0
Jun-15	9	20	XX	888	100	1.0									0
Jun-15	11	30	XX	888	100	1.0									0
Jun-15	12	10	XX	777	100	8.8									0
Jun-15	12	23	XX	113	100	9.0	4	5	.606	1.501	2.584	.059	.267	.007	1049
Jun-15	12	27	XX	999	100	8.8	4	5							
Jun-15	14	50	XX	116	100	9.0	4	5	.078	.782	.558	.072	.082	.020	490
Jun-15	15	55	XX	999	100	9.0	8	10							
Jun-15	16	2	XX	999	100	9.0	8	10							
Jun-16	10	48	XX	999	100	8.5	13	15							
Jun-16	13	6	XX	121	100	8.0	13	15	.008	.065	.030	.016	.008	.003	61
Jun-16	15	45	XX	999	100	1.0	15	15							
Jun-16	16	30	XX	888	100	1.0	15	15							
Jun-16	19	15	XX	777	100	1.0	15	15							
Jun-17	10	45	XX	126	100	8.8	17	20	.016	.081	.082	.012	.015	.003	68
Jun-17	11	0	XX	888	100	1.0									
Jun-17	11	40	XX	777	100	1.0									
Jun-17	15	0	XX	128	500	10.0	4	5	.053	.339	.213	.070	.041	.017	280
Jun-18	10	0	XX	132	500	7.8	4	5	.049	.339	.215	.061	.044	.016	256
Jun-19	10	30	XX	135	500	7.1	4	5	.038	.424	.256	.055	.048	.017	296
Jun-19	10	47	XX	888	100	1.0									
Jun-19	11	40	XX	888	100	1.0									
Jun-20	9	20	XX	888	100	1.0									
Jun-20	9	50	XX	888	100	1.0									
Jun-20	10	35	XX	888	100	1.0									
Jun-20	15	0	XX	888	100	1.0									
Jun-21	9	0	XX	888	100	1.0									
Jun-21	9	33	XX	888	100	1.0									
Jun-21	10	30	XX	777	100	1.0									
Jun-22	10	0	XX	140	500	14.6	4	5	.094	.588	.692	.047	.101	.017	364
Jun-22	16	10	XX	145	500	14.4	4	5	.081	.663	.690	.057	.124	.022	415
Jun-23	10	0	XX	146	500	14.5	4	5	.095	.899	.856	.071	.136	.032	556
Jun-24	11	0	XX	154	500	14.5	4	5	.019	.202	.211	.017	.033	.009	135
Jun-24	14	30	XX	888	500		5	5							
Jun-24	16	34	XX	999	500	10.0	4	5							
Jun-24	16	50	XX	999	500	8.7	4	5							
Jun-24	17	35	XX	999	500	8.9	4	5							
Jun-25	9	15	XX	999	500	8.0	4	5							
Jun-27	11	30	XX	160	500	6.8	4	5	.026	.437	.290	.069	.041	.036	277
Jun-27	16	0	XX	888	500	6.8	4	5							

Preliminary data

ECC SOILS DATA
TERRA VAC PILOT TEST

	HEW-1	HEW-1	HEW-1	HEW-1	HEW-1	HEW-1		HEW-1	HEW-1
	SOIL CONCENTRATION (PPM)								
	DEPTH FT.	DCE ppm	TCA ppm	BZ ppm	TCE ppm	TOL ppm	PCE ppm	mp-XYL ppm	TOTAL ppm
1-3-3	3.0	.2	3.2	NA	7.7	1.9	4.5	1.9	19.4
1-6-7	7.0	.4	2.4	NA	4.5	2.1	9.6	2.2	9.4
6-9	9.0	.1	.0	NA	.0	.0	.1	.0	.2
12-4	4.0	2.4	59.6	NA	99.7	5.1	187.5	2.3	166.7
12-7	7.0	4.5	63.9	NA	125.0	5.9	155.2	2.2	199.3
20-2	2.0	6.8	18.3	NA	59.0	10.6	2.4	2.9	94.5
25-7	7.0	3.9	3.8	NA	24.5	4.0	11.5	1.7	41.1
35-5	5.0	7.7	45.6	NA	7.9	4.6	4.0	1.8	65.7
35-6	6.0	62.3	96.2	NA	49.7	9.4	103.1	3.8	217.6
40-3	3.0	6.3	4.3	NA	2.0	.5	1.6	.2	13.1
40-5	5.0	1.5	22.4	NA	2.6	1.0	1.1	.5	27.5
40-7	7.0	.7	67.4	NA	9.0	6.9	1.9	.6	84.1

	HEW-2		HEW-2	HEW-2	HEW-2	HEW-2	HEW-2	HEW-2	HEW-2
	SOIL CONCENTRATION (PPM)								
	DEPTH FT.	DCE ppm	TCA ppm	BZ ppm	TCE ppm	TOL ppm	PCE	mp-XYL	TOTAL ppm
2-5-3	3.0	.6	3.6	NA	6.5	3.3	1.5	2.3	14.0
5-7	7.0	1.1	180.8	NA	10.6	19.7	4.9	8.8	212.1
5-9	9.0	.2	5.1	NA	8.5	1.2	8.7	1.0	15.0
15-2	2.0	1.5	109.6	NA	6.8	15.3	2.1	3.4	133.2
15-8	8.0	1.1	83.0	NA	16.2	13.9	2.2	4.9	114.1
18-5	5.0	1.1	40.2	NA	12.0	.8	1.9	.1	54.2
22-3	3.0	.4	54.7	NA	20.1	4.0	4.7	1.8	79.1
22-8	8.0	.1	1.8	NA	.7	.4	.2	.2	3.0
35-3	3.0	1.6	37.9	NA	58.7	18.1	26.4	10.1	116.2
35-4	4.0	.6	54.5	NA	333.9	25.5	35.0	6.4	414.4
35-7	7.0	1.4	68.9	NA	71.3	19.2	20.6	13.7	160.7
43-5	5.0	2.5	153.5	NA	24.8	13.3	5.6	5.8	194.1
45-2	2.0	.9	68.9	NA	21.7	12.5	3.5	4.1	103.9
45-6	6.0	1.6	116.8	NA	15.4	14.1	2.5	4.6	147.8

T2-5-3 = HEW-2 sample, 5 ft from end of trench at 3 ft depth

SAMPLE TIME DATE	HRS	MIN	XX HEW-1	SAMP NUM	INJ VOL (ul)	WELL VAC ("Hg)	FLOW RATE (SCFM)	FLOW RATE (ACFM)	1,1 DCE (mg/l)	1,1,1 TCA (mg/l)	TCE (mg/l)	TOL (mg/l)	PCE (mg/l)	M,P-XYL (mg/l)	TOTAL AREA 1000X
				((OPERATION DATA))					HEW-1 ((GAS CHROMATOGRAPH READOUT))						
Jun-14	12	17	XX	888											
Jun-14	12	18	XX	888	100	1.0									
Jun-14	12	38	XX	888	100	1.0									
Jun-14	13	18	XX	888	100	1.0									
Jun-14	13	31	XX	888	100	1.0									
Jun-14	14	31	XX	888	100	1.0									
Jun-14	15	31	XX	888	100	1.0									
Jun-14	15	40	XX	888	100	1.0									
Jun-14	16	29	XX	888	100	1.0									
Jun-14	17	29	XX	888	100	1.0									
Jun-14	20	42	XX	888	100	1.0									
Jun-15	8	39	XX	888	100	1.0									
Jun-15	9	20	XX	888	100	1.0									
Jun-15	11	30	XX	888	100	1.0									
Jun-15	12	10	XX	888	100	1.0									
Jun-15	12	23	XX	777	100	1.0									
Jun-15	12	27	XX	114	100	8.5	2	2	.377	1.380	.701	.034	1.015	.008	1210
Jun-15	14	50	XX	115	100	9.5	17	20	.040	.241	.107	.030	.170	.015	194
Jun-15	15	55	XX	999	100	9.5	17	20							
Jun-15	16	2	XX	999	100	9.5	25	30							
Jun-16	10	48	XX	999	100	9.5	33	40							
Jun-16	13	6	XX	122	100	8.8	34	40	.012	.065	.027	.006	.049	.003	44
Jun-16	15	45	XX	999	100	8.8	34	40							
Jun-16	16	30	XX	888	100	1.0	39	40							
Jun-16	19	15	XX	777	100	1.0	52	53							
Jun-17	10	45	XX	124	100	8.4	68	80	.009	.054	.022	.003	.036	.001	54
Jun-17	11	0	XX	888	100	1.0									
Jun-17	11	40	XX	777	100	1.0									
Jun-17	15	0	XX	127	500	9.7	82	100	.031	.227	.090	.018	.163	.007	158
Jun-18	10	0	XX	131	500	7.2	90	103	.022	.192	.085	.013	.130	.005	102
Jun-19	10	30	XX	134	500	6.8	114	130	.014	.187	.090	.012	.147	.004	152
Jun-19	10	47	XX	888	100	1.0									
Jun-19	11	40	XX	888	100	1.0									
Jun-20	9	20	XX	888	100	1.0									
Jun-20	9	50	XX	888	100	1.0									
Jun-20	10	35	XX	777	100	1.0									
Jun-20	15	0	XX	138	500	9.5	141	170	.013	.161	.074	.011	.133	.004	78
Jun-21	9	0	XX	139	1000	7.8	185	215	.020	.291	.138	.023	.255	.009	179
Jun-21	9	33	XX	888	100	1.0									
Jun-21	10	30	XX	888	100	1.0									
Jun-22	10	0	XX	888	100	1.0									
Jun-22	16	10	XX	888	100	1.0									
Jun-23	10	0	XX	888	100	1.0									
Jun-24	11	0	XX	888	100	1.0									
Jun-24	14	30	XX	888	100	1.0									
Jun-24	16	34	XX	888	100	1.0									
Jun-24	16	50	XX	888	100	1.0									
Jun-24	17	35	XX	888	100	1.0									
Jun-25	9	15	XX	888	100	1.0									
Jun-27	11	30	XX	888	100	1.0									
Jun-27	16	0	XX	888	100	1.0									

Preliminary data

HEW-2

DATE	HRS	MIN	XX	SAMP NUM	INJ VOL (ul)	WELL VAC ("Hg)	FLOW RATE (SCFM)	FLOW RATE (ACFM)	1,1 DCE (mg/l)	1,1,1 TCA (mg/l)	TCE (mg/l)	TOL (mg/l)	PCE (mg/l)	M,P-XYL (mg/l)	TOTAL AREA 1000X
					<< OPERATION DATA >>				<< GAS CHROMATOGRAPH READOUT >>						
Jun-14	12	17	XX	777											0
Jun-14	12	18	XX	106	100	10.0	4	5	.163	1.170	1.150	.094	.200	.019	1020
Jun-14	12	38	XX	107	100	10.0	4	5	.146	1.890	.863	.121	.109	.024	1105
Jun-14	13	18	XX	108	100	10.0	4	5	.162	1.870	.791	.129	.132	.031	930
Jun-14	13	31	XX	888	100	10.0	4	5							
Jun-14	14	31	XX	777	100	10.0	4	5							
Jun-14	15	31	XX	109	100	7.5	4	5	.128	2.216	.903	.171	.131	.048	990
Jun-14	15	40	XX	888	100	8.0	4	5							
Jun-14	16	29	XX	777	100	9.0	4	5							
Jun-14	17	29	XX	110	100	8.5	8	10	.103	1.953	.915	.182	.138	.057	929
Jun-14	20	42	XX	111	100	9.0	8	10	.077	1.328	.823	.152	.130	.051	728
Jun-15	8	39	XX	888	100	9.3	17	20							
Jun-15	9	20	XX	777	100	9.0	17	20							
Jun-15	11	30	XX	112	100	9.0	17	20	.046	.724	.626	.104	.104	.036	475
Jun-15	12	10	XX	999	100	10.0	16	20							
Jun-15	12	23	XX	999	100	10.0	16	20							
Jun-15	12	27	XX	999	100	9.0	17	20							
Jun-15	14	50	XX	999	100	8.5	17	20							
Jun-15	15	55	XX	117	100	9.5	17	20	.036	.520	.491	.077	.084	.025	358
Jun-15	16	2	XX	999	100	8.5	25	30							
Jun-16	10	48	XX	999	100	9.0	33	40							
Jun-16	13	6	XX	120	100	9.1	38	45	.020	.266	.283	.042	.051	.012	191
Jun-16	15	45	XX	999	100	9.0	38	45							
Jun-16	16	30	XX	888	100	1.0	44	45							
Jun-16	19	15	XX	777	100	12.0	54	70							
Jun-17	10	45	XX	125	100	7.8	106	123	.014	.134	.162	.021	.034	.007	143
Jun-17	11	0	XX	888	100	1.0	0								
Jun-17	11	40	XX	777	100	1.0	0								
Jun-17	15	0	XX	129	100	9.0	115	138	ND	.060	.081	.011	.018	.003	50
Jun-18	10	0	XX	133	500	6.3	146	164	.021	.232	.354	.054	.079	.019	223
Jun-19	10	30	XX	136	500	5.8	202	225	.012	.164	.271	.039	.050	.015	199
Jun-19	10	47	XX	888	100	1.0	0								
Jun-19	11	40	XX	777	100	1.0	0								
Jun-20	9	20	XX	137	500	7.0	210	240	nd	.115	.214	.032	.040	.012	188
Jun-20	9	50	XX	888	100	1.0	0								
Jun-20	10	35	XX	868	100	1.0	0								
Jun-20	15	0	XX	888	100	1.0	0								
Jun-21	9	0	XX	888	100	1.0	0								
Jun-21	9	33	XX	888	100	1.0	0								
Jun-21	10	30	XX	868	100	1.0	0								
Jun-22	10	0	XX	888	100	1.0	0								
Jun-22	16	10	XX	888	100	1.0	0								
Jun-23	10	0	XX	888	100	1.0	0								
Jun-24	11	0	XX	888	100	1.0	0								
Jun-24	14	30	XX	888	100	1.0	0								
Jun-24	16	34	XX	777	100	1.0	0								
Jun-24	16	50	XX	155	500	7.2	205	235	.027	.551	.391	.067	.087	.028	377
Jun-24	17	35	XX	156	500	7.2	205	235	.020	.362	.333	.055	.072	.023	259
Jun-25	9	15	XX	157	500	5.9	233	260	.011	.135	.209	.030	.037	.012	184
Jun-27	11	30	XX	159	500	4.3	315	340	.006	.051	.118	.023	.020	.007	78
Jun-27	16	0	XX	160	1000	4.2	315	340	.012	.101	.244	.048	.040	.016	197

Preliminary data

APPENDIX B

SITE SPECIFIC EVALUATION OF VAPOR EXTRACTION

SITE SPECIFIC EVALUATION OF VAPOR EXTRACTION APPLICATION

INTRODUCTION

Vapor extraction is a process used to remove volatile pollutants from contaminated soils (1,2,3,4). The process works by withdrawing volatile contaminants from soil, in situ. A subsurface vacuum is propagated from extraction wells which causes vapors to migrate to the extraction wells. The vapors are brought from the wells to the surface where they are collected and treated.

The effectiveness of the vapor extraction process is influenced by the contaminant volatility, the soil stratigraphy and the location of the ground water table. The implementation of vapor extraction therefore requires site specific evaluation. This report describes a procedure to evaluate the application of vapor extraction technology for a particular site.

SUMMARY OF METHODOLOGY

A site investigation must be performed to determine the type, extent and severity of contamination. A CERCLA remedial investigation is generally sufficient for this purpose. Certain data collected from the site are scored and weighted to determine the feasibility of vapor extraction for the given site. Based on the calculated feasibility score, a decision is made either to reject vapor extraction for the site, to reevaluate alternative technologies, or to conduct a vapor extraction pilot test.

If site conditions (as defined by the feasibility score) are favorable, pilot tests are performed. Performance data from the pilot test are then evaluated through a scoring and weighting procedure analogous to the feasibility scoring procedure. A decision is made either to reject the vapor extraction process as unsuitable for the site conditions, to reevaluate alternative technologies, or to affirm that the vapor extraction process can be applied to the site. The methodology is graphically depicted in Figure 1.

SITE SPECIFIC DATA REQUIREMENTS

Site remedial investigation activities provide the data needed to support decisions made in feasibility studies. Vapor extraction is dependent upon the ability of contaminants to volatilize and move through the soils to a collection system. A site characterization study must therefore define the types and extent of contamination on a site and the soil matrix in which the contaminants are found. Specifically, the site investigation must define the contaminants, their distribution and the soil classification on a site.

The site characterization study must also define the percent of total contamination in the unsaturated zone. If a significant portion of the total contaminant mass is contained in the saturated zone, the feasibility of dewatering must also be defined. Superfund site remedial investigation/feasibility studies typically provide the site characteristic data described above.

FEASIBILITY ANALYSIS

Assuming that the required data are available, a feasibility analysis is performed to determine if the vapor extraction process should be considered for a site. Initially the most important concern is the volatility of the contaminants (2,5). The volatility of the compounds will determine their transport from the liquid phase as attached to soil particles to the vapor phase in the soil gas.

Volatility

For evaluation purposes, volatility is indicated by Henry's Law constants. The use of adsorption isotherms to account for the soil/liquid interaction is desirable but adsorption coefficients are generally unavilable for most compounds and soil types (6). Contaminants with Henry's Law constants greater than 10^{-4} (atm-m^3/mol) are considered amenable to removal by vapor extraction. Compounds with Henry's Law constants less than 10^{-7} should be considered essentially nonvolatile (7) and are poor candidates for evaporative technologies. Compounds with Henry's Law constants in the range of 10^{-4} to 10^{-7} are considered fair candidates for vapor extraction.

Stratigraphy

The second factor of concern is the transport of vapor from the soil to the collection system. This transport is dependent on the vacuum developed on the site (which is a process operation parameter) and the characteristics of the soil. The movement of gasses in porous media is described by Darcy's Law (6). The coefficient of permeability used in Darcy's law to describe the transport of ground water through soil may be used to characterize the flow of other fluids through soil such as air or vapor. Soil permeability may be estimated based on a classification of the representative materials in the soil. Sandy soils which generally have a coefficient of permeability greater than 10^{-3} ($cm^3/cm^2/sec$)(8) are good candidates for the use of the vapor extraction process. Mixed soils with coefficients of permeability between 10^{-3} and 10^{-6} are considered fair candidates for the application of this technology. Soils with coefficients of permeability less than 10^{-6} are considered poor candidates for the application of this technology.

Ground Water

The presence of ground water will inhibit the transport of volatile pollutants from the saturated soil matrix to the soil gas above. If 90% of the total mass of pollutants are in the unsaturated zone of the soil, this site is considered a good candidate for the application of vapor extraction. If a significant mass of pollutants is in the saturated zone, dewatering may be used to remove the ground water and enhance the transport of pollutants from the soil matrix. The practicality of dewatering a site is dependent on the depth, soil material, dewatering area, ground water recharge, and discharge requirements for the ground water. Hydrogeologic and ground water quality data must be available to evaluate the ability to dewater a site. If greater than 10% of the total mass of pollutants on-site is in the saturated zone and dewatering is feasible, a site is considered to be a fair candidate for vapor extraction. If greater than 10% of the total mass of pollutants is below the saturated zone and the site is difficult to dewater, then the site is considered to be a poor candidate for vapor extraction.

Initial Screening Score

The overall evaluation of a site uses the weights and parametric scores as shown in Table 1. The primary parameter is the volatility of the contaminants which is given a weighting factor of 3. The transport characteristics of the contaminants in the soil are of secondary importance and are weighted with a factor of 2. Finally, the potential for ground water interference is weighted with a factor of 1. The values of the parameters are scored as good (80 points), fair (60 points), or poor (30 points) as shown in Table 1.

An overall score is then calculated according to Equation 1 on Table 1. This score is used to evaluate the feasibility of using vapor extraction technology on a particular site. A score of 60 or more generally indicates that use of the technology is feasible and that a pilot test should be conducted. A score less than 60 but greater than or equal to 50 is marginal and indicates a need to reevaluate alternate technologies. A score of less than 50 indicates that vapor extraction technology is not appropriate for the site and should not be selected for use as a remediation technology.

PERFORMANCE ANALYSIS

It is necessary to perform a pilot test to determine how the process will perform for a particular application. The pilot test is used to determine the zone of influence of the vapor extraction well, the initial pollutant mass extraction rate, and the necessity for emission controls. These parameters, in addition to the site stratigraphy and contaminant distribution, are critical to determining the cost of a vapor extraction system.

Zone of Influence

The radial zone of influence of a well will determine the number of extraction wells required. The zone of influence is a function of the air extraction rate and the extraction well negative pressure. As the zone of influence increases, the number of extraction wells required decrease.

Initial Extraction Rate

The initial extraction rate will determine the length of time an extraction system must be operated. The contaminant mass extraction rate may be determined by multiplying the air extraction rate by the extracted air contaminant concentration. Since the contaminant distribution is known from the site investigation, the extraction rate may be expressed as a percent of the total contaminant mass. The initial extraction rates can be used to estimate the total operating time for site remediation.

Emission Controls

Emission controls may be used to reduce the concentration of the extracted air contaminants. Emmission controls may be applied during the early stages of a vapor extraction remediation project, when the mass extraction rate is likely to be high. Emmission controls will increase the cost of a system.

Pilot Test Screening Score

These three factors are as shown in Table 2. A performance analysis score is then calculated using Equation 1 (Table 1). If the score is less than 50 points, the vapor extraction technology is rejected as impractical. If the score be greater than or equal to 50 but less than 60, the alternative technologies should be reevaluated. If the score is greater than 60 the process is recommended for the site.

Verification of Clean Up

Final soil contaminant concentrations may be calculated using mass balance techniques based on the difference between the initial contaminant mass on site and the field determined mass extraction rate. Soil samples may be collected to confirm calculated results. Alternatively, laboratory soil aeration studies may be conducted on field collected samples to determine an effective Henry's Law factor. This factor would incorporate soil adsorption effects and other interferences expected under field conditions. This factor, the gas flow rate and soil characteristics may be used to estimate the aeration time required to meet final contaminant concentration clean up standards (6). However, laboratory studies may require from 4 weeks to 6 months (5) and will not eliminate the need for pilot testing.

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TABLE 1

VAPOR EXTRACTION FEASIBILITY ANALYSIS TABLE

	Parameter		
Rating	Contaminant Henry's Law Constant ($atm\text{-}m^3/mol$) (wf=3)	Soil Permeability ($cm^3/cm^2/sec$) (wf=2)	Ground Water Interference (wf=1)
Good (Score 80)	$K_h > 10^{-4}$	Sands $K>10^{-3}$	90% of total contaminant mass in unsaturated zone
Fair (Score 60)	$10^{-7} < K_h < 10^{-4}$	Mixed soils $10^{-6}<K<10^{-3}$	>10% in saturated zone, feasible dewatering
Poor (Score 30)	$K_h<10\text{-}7$	Clays $K<10^{-6}$	>10% in saturated zone, difficult dewatering

wf = Weighting Factor

Equation 1. Score = $S_T = \sum S_i W_j / \sum W_j$

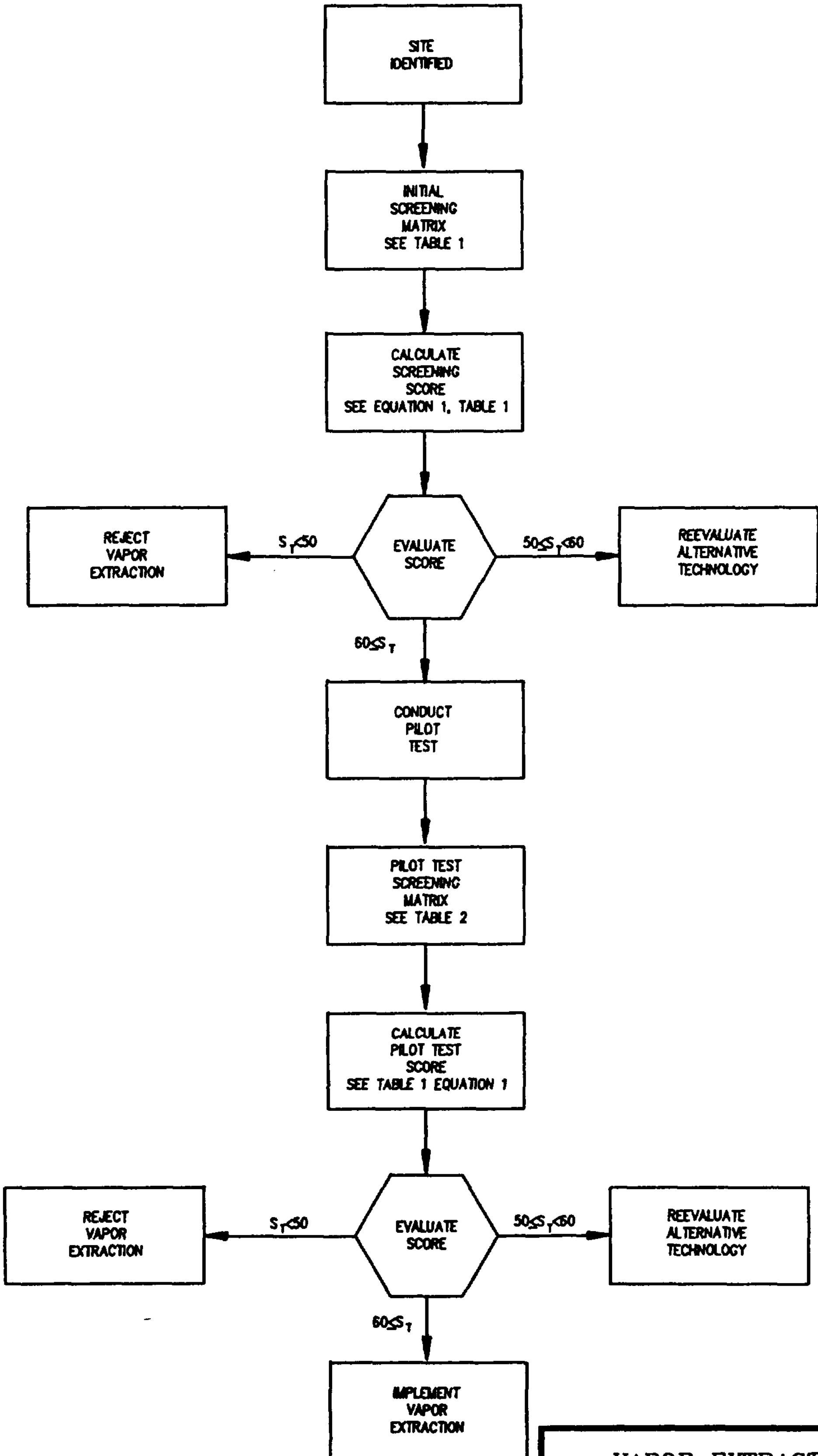
where: S_T = total score
S_i = score for parameter i
W_j = weighting factor for parameter

TABLE 2

VAPOR EXTRACTION PERFORMANCE ANALYSIS TABLE

Rating	Zone of Influence (wf=3)		Initial Contaminant Mass Extraction Rate (wf=2)	Emmission Controls Required (wf=1)
	Sands	Clays		
Good (Score 80)	>50 ft.	>20 ft.	>5% total mass on site/day	None
Fair (Score 60)	20<ZOI<50	10<ZOI<20	1%/day<ER<5%/day	During Initial Remediation
Poor (Score 30)	<25 ft.	<10 ft.	<1%/day	Continuously During Remediation

wf = Weighting Factor
ZOI = Zone of Influence
ER = Extraction Rate



VAPOR EXTRACTION EVALUATION

FIGURE 1

ERM ERM–North Central, Inc.

ATTACHMENT 2

TERRA VAC PILOT TEST
AT
ENVIRONMENTAL CHEMICAL AND CONSERVATION CORP.
ZIONSVILLE, INDIANA

INTRODUCTION

This report discusses the results of the vapor extraction pilot test conducted by Terra Vac with ERM-North Central at the Environmental Chemical and Conservation Corporation (ECC) NPL site in Zionsville, Indiana. The report discusses the major project activities, data gathered, and significant findings in the following sections:

I. Summary
II. System Installation
III. Vapor Extraction Operations
IV. Analytical QA/QC
V. Projection of Clean-Up Time

I. SUMMARY

The vapor extraction pilot test was successful in demonstrating the Terra Vac Process as a technically sound and cost effective method for removing volatile organics from the ECC site soils. Horizontal extraction wells were shown to be superior to vertical extraction wells for the site geology. Clean up time for the site using vapor extraction was estimated to be 300-400 days.

During Terra Vac's pilot test and operating period, approximately 548 pounds of VOCs were removed from the soil at the site. Tests show an approximate 20 foot radius of influence for horizontal extraction wells. The extended run time on HEW-2 developed the data necessary to project clean up time. The vapor extraction operations began on June 13 and continued, with only minor shut downs, until July 20.

II. SYSTEM INSTALLATION

During the week of June 1, Terra Vac personnel arrived on site to receive and procure materials for the job. Trenching began on June 7 and continued until June 8. Subsurface vapor monitoring wells and Vertical Extraction Well (VEW-1) were installed during the remainder of the week. Following extraction trench installation, the major components of the extraction system were manifolded together. Figure 1 is a drawing showing the layout of the test site.

During trench installation soil samples were taken and analyzed for VOCs using the headspace method. As expected, the VOC concentration was highly variable over the length of the trench. Table 1 is a summary of the chemical analyses of the soil samples.

III. VAPOR EXTRACTION OPERATIONS

Appendix A is a daily summary of the system and the operation of each well. Appendix B contains operating and analytical data taken during the pilot test.

A. Well Development

HEW-2 was initially developed for 22 hours. The results of the development period showed high VOC extraction rates and a radius of influence extending to approximately 15 feet. Following development of HEW-2, vapor extraction from HEW-1 and VEW-1 was initiated as a combined development. The combined development continued for approximately four more days. The results of that development period indicated that HEW-1 had lower VOC extraction rates than HEW-2 but a comparable radius of influence. However, no significant radius of influence was measured from the vertical extraction well (VEW-1).

B. Operations

Figure 2 is a plot of the Cumulative Pounds of VOC Extracted by the System versus Run Time. Approximately 548 pounds of VOC were removed from the soil at the site during Terra Vac's operations. After well development, operations focussed on HEW-2, where VOC concentrations were expected and found to be highest. HEW-2 remained in operation for a total of 31.4 days, with a total of 470.8 pounds of VOCs removed, as shown in Figure 3. The radius of influence stabilized at 15 to 20 feet.

Figure 4 and 5 show cumulative VOCs removed from HEW-1 and VEW-1. The short run times reflect both the slow development of VEW-1 and the decision to operate HEW-2 solely. Following development, the unexpectedly high flow rates from HEW-2 necessitated its solo operation so that the pilot system's effectiveness could be maximized.

Figure 6 shows HEW-2 VOC removal rates vs. run time. This type of curve is consistent with Terra Vac's previous experience. Early high rates decline to a relatively stable removal rate that slowly decreases (spikes before day 10 were caused by optimization procedures or short term shutdowns). Figure 7, showing initial and final rates for the major contaminants at HEW-2, indicates how these changes in VOC removal rate occur. There are substantial drops in rates from beginning to end for the more volatile components such as DCE, TCA, and TCE, while rates for Toluene, PCE, and Xylenes have changed little or increased. The Total VOC Removal Rate dropped by 87% from its high point of 76 lb/day to a low point of 9.9 lb/day when the system was shut off.

The extracted VOCs were exhausted using a dispersion stack with agreement from the Indiana Department of Environmental Protection. Air quality testing was performed at the site boundary by ERM-North Central using a hand held vapor analyzer with a photoionization detector. At no time did concentrations of the indicator compounds at the site boundary exceed allowable limits.

IV. ANALYTICAL QA/QC

Several attachments (1-4) are included in this report that outline GC parameters, sampling and QC procedures. Vapor analyses were by direct injection of samples into a Shimadzu GC-9A gas chromatograph equipped with a flame ionization detector and utilizing a capillary column for separation of the compounds. Calibration checks or recalibrations were done daily, prior to sampling. All sample syringes were air purged via pump, with several blanks run to verify efficiency of purging procedure. Questionable results (i.e., an unusual change in concentration) was cause to run a syringe blank and resample to verify initial analysis.

V. PROJECTION OF CLEAN-UP TIME

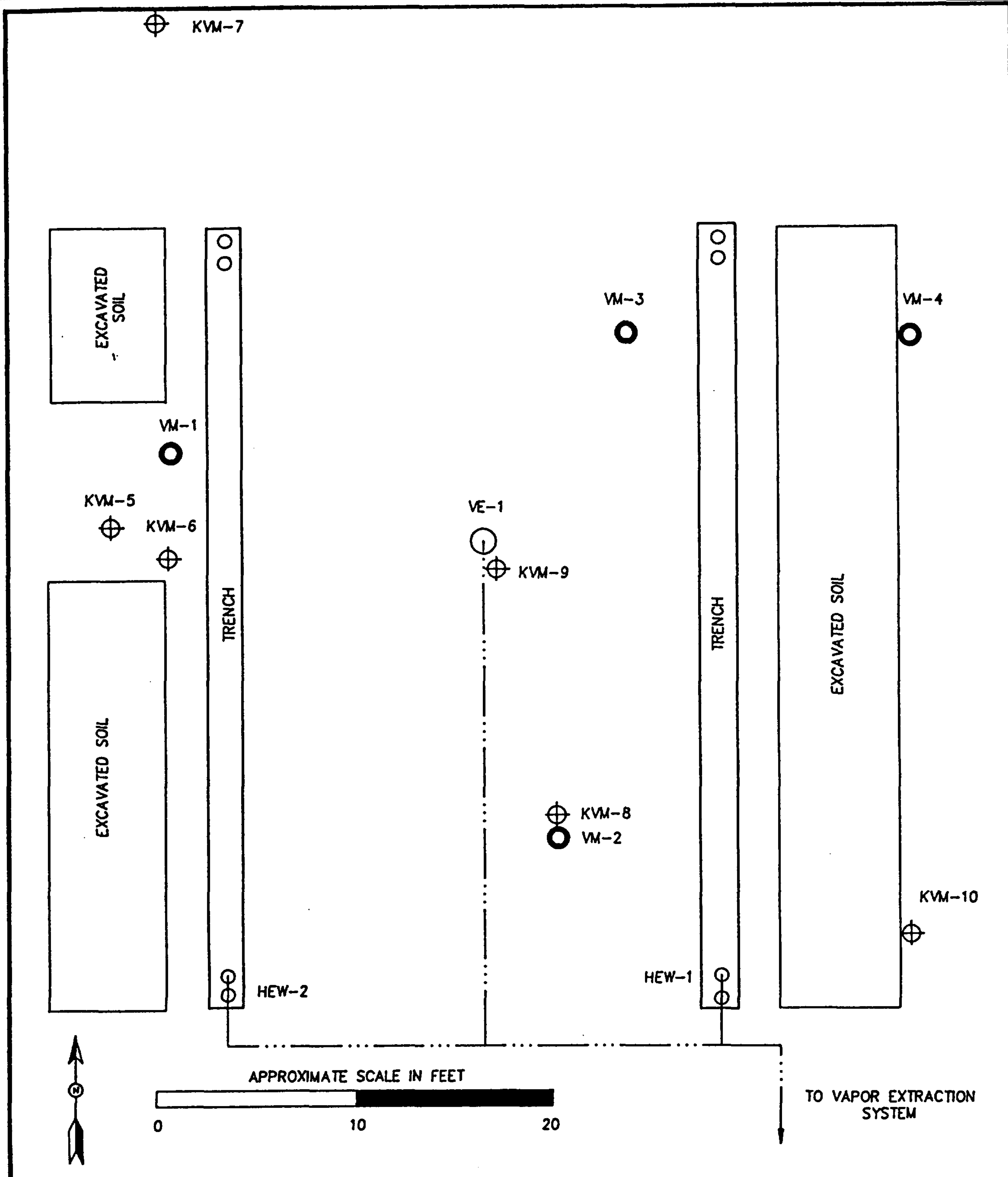
Based upon data collected from the operation of HEW-2, the clean-up time for the site using vapor extraction technology is projected to be approximately 350 days.

TABLE ONE

ECC SOILS DATA
TERRA VAC PILOT TEST

HEW-1	HEW-1	HEW-1	HEW-1	HEW-1	HEW-1	HEW-1		HEW-1	HEW-1
SOIL	SOIL CONCENTRATION (PPM)								
SAMPLE ID	DEPTH FT.	DCE ppm	TCA ppm	BZ ppm	TCE ppm	TOL ppm	PCE ppm	mp-XYL ppm	TOTAL ppm
T1-3-3	3.0	.2	3.2	NA	7.7	1.9	4.5	1.9	19.4
T1-6-7	7.0	.4	2.4	NA	4.5	2.1	9.6	2.2	9.4
T1-6-9	9.0	.1	.0	NA	.0	.0	.1	.0	.2
T1-12-4	4.0	2.4	59.6	NA	99.7	5.1	187.5	2.3	166.7
T1-12-7	7.0	4.5	63.9	NA	125.0	5.9	155.2	2.2	199.3
T1-20-2	2.0	6.8	18.3	NA	59.0	10.6	2.4	2.9	94.5
T1-25-7	7.0	3.9	8.8	NA	24.5	4.0	11.5	1.7	41.1
T1-35-5	5.0	7.7	45.6	NA	7.9	4.6	4.0	1.8	65.7
T1-35-6	6.0	62.3	96.2	NA	49.7	9.4	103.1	3.8	217.6
T1-40-3	3.0	6.3	4.3	NA	2.0	.5	1.6	.2	13.1
T1-40-5	5.0	1.5	22.4	NA	2.6	1.0	1.1	.5	27.5
T1-40-7	7.0	.7	67.4	NA	9.0	6.9	1.9	.6	84.1

HEW-2	HEW-2		HEW-2	HEW-2	HEW-2	HEW-2	HEW-2	HEW-2	HEW-2
SOIL	SOIL CONCENTRATION (PPM)								
SAMPLE ID	DEPTH FT.	DCE ppm	TCA ppm	BZ ppm	TCE ppm	TOL ppm	PCE	mp-XYL	TOTAL ppm
T2-5-3	3.0	.6	3.6	NA	6.5	3.3	1.5	2.3	14.0
T2-5-7	7.0	1.1	180.8	NA	10.6	19.7	4.9	8.8	212.1
T2-5-9	9.0	.2	5.1	NA	8.5	1.2	8.7	1.0	15.0
T2-15-2	2.0	1.5	109.6	NA	6.8	15.3	2.1	3.4	133.2
T2-15-8	8.0	1.1	83.0	NA	16.2	13.8	2.2	4.9	114.1
T2-18-5	5.0	1.1	40.2	NA	12.0	.8	1.9	.1	54.2
T2-22-3	3.0	.4	54.7	NA	20.1	4.0	4.7	1.8	79.1
T2-22-8	8.0	.1	1.8	NA	.7	.4	.2	.2	3.0
T2-35-3	3.0	1.6	37.9	NA	58.7	18.1	26.4	10.1	116.2
T2-35-4	4.0	.6	54.5	NA	333.9	25.5	35.0	6.4	414.4
T2-35-7	7.0	1.4	68.9	NA	71.3	19.2	20.6	13.7	160.7
T2-43-5	5.0	2.5	153.5	NA	24.8	13.3	5.6	5.8	194.1
T2-45-2	2.0	.9	68.9	NA	21.7	12.5	3.8	4.1	103.9
T2-45-6	6.0	1.6	116.8	NA	15.4	14.1	2.5	4.6	147.8



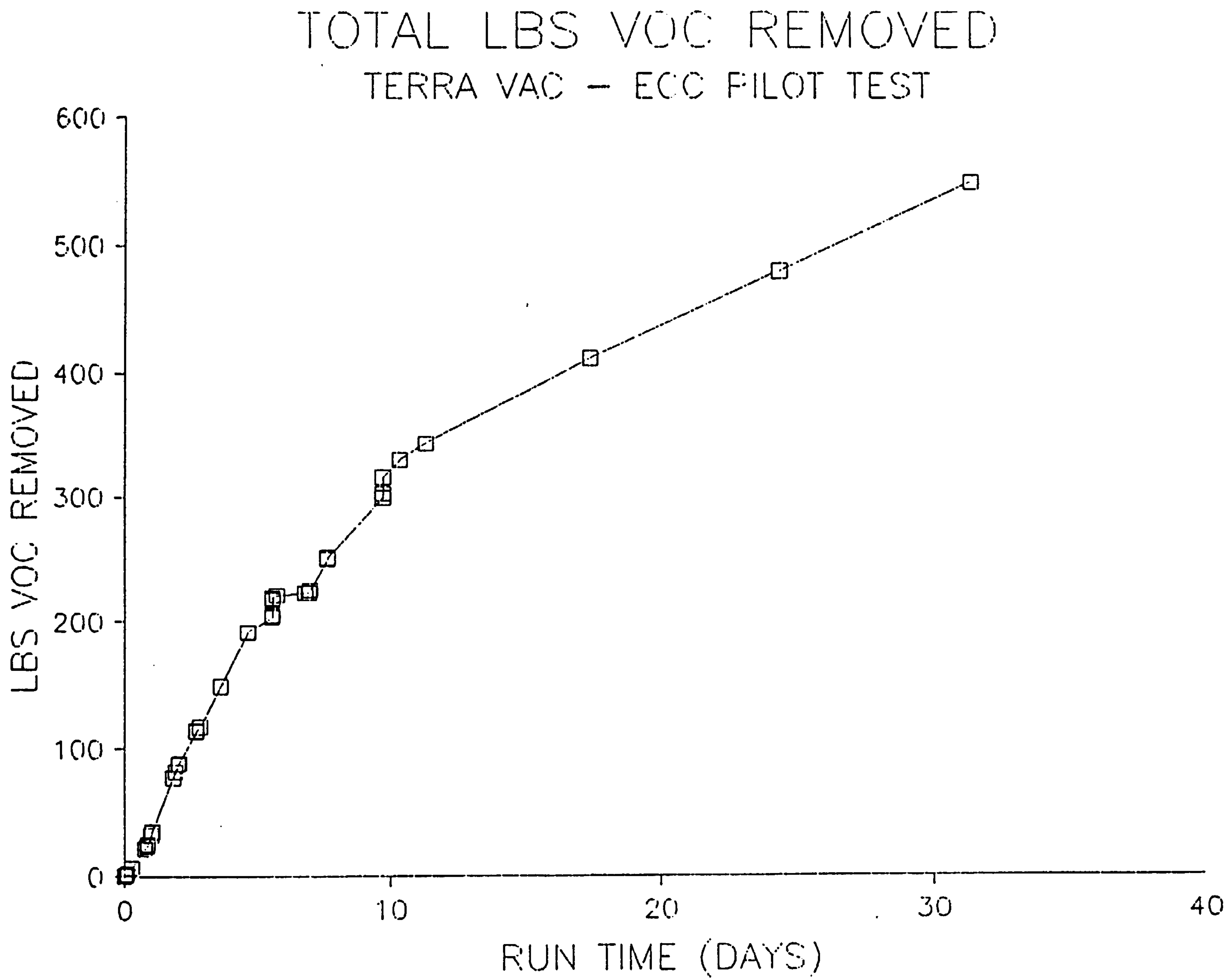
ECC SITE
SOIL VAPOR EXTRACTION SYSTEM
PILOT TEST LAYOUT

FIGURE 1

ERM ERM-North Central, Inc.

mo

FIGURE 2



TOTAL LBS VOC REMOVED
TERRA VAC — ECC FILOT TEST
LBS VOC REMOVED
RUN TIME (DAYS)
0
100
200
300
400
500
600
0
10
20
30
40

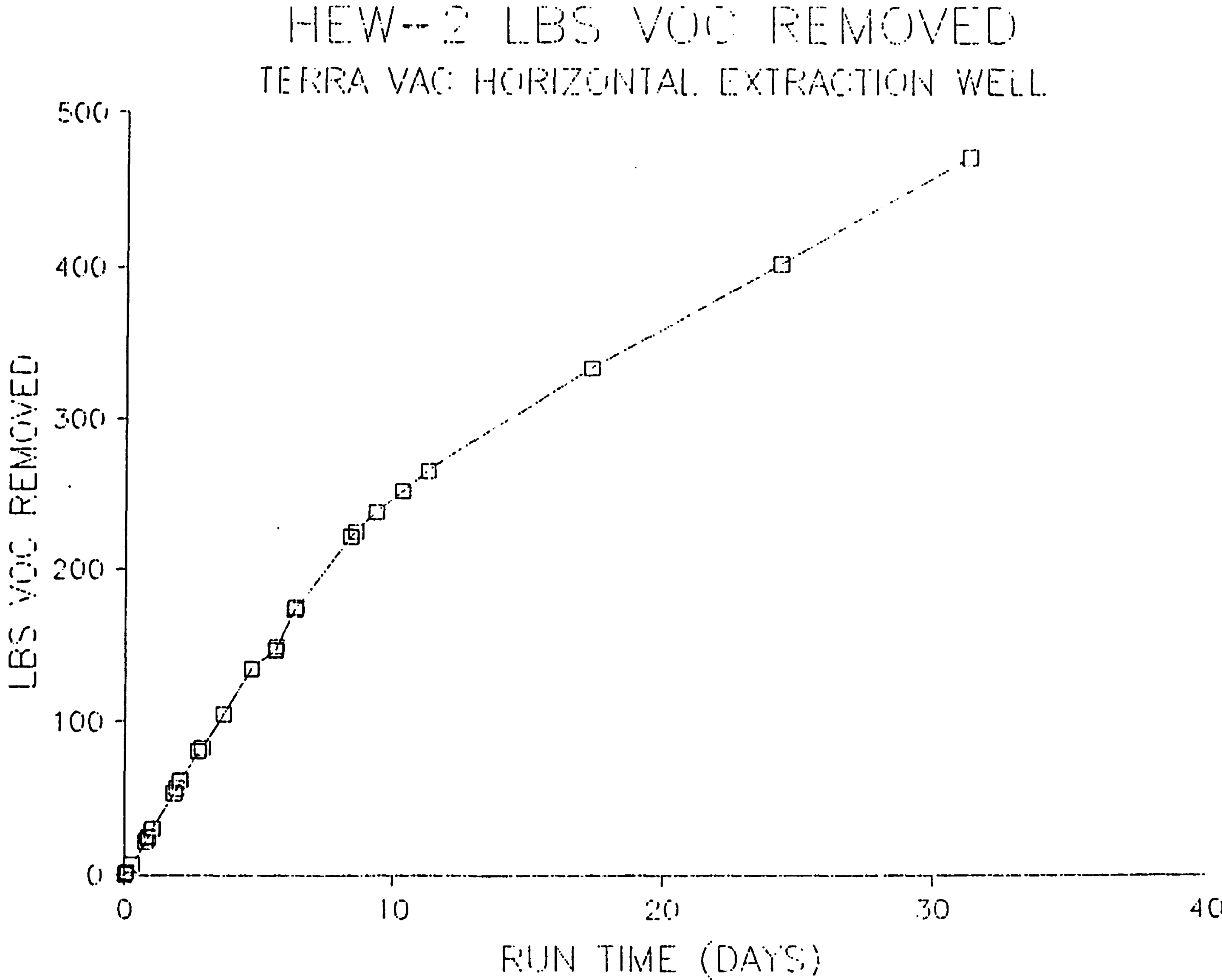

HEW-2 LBS VOC REMOVED
TERRA VAC HORIZONTAL EXTRACTION WELL
LBS VOC REMOVED
500
400
300
200
100
0
0
10
20
30
40
RUN TIME (DAYS)

FIGURE 3

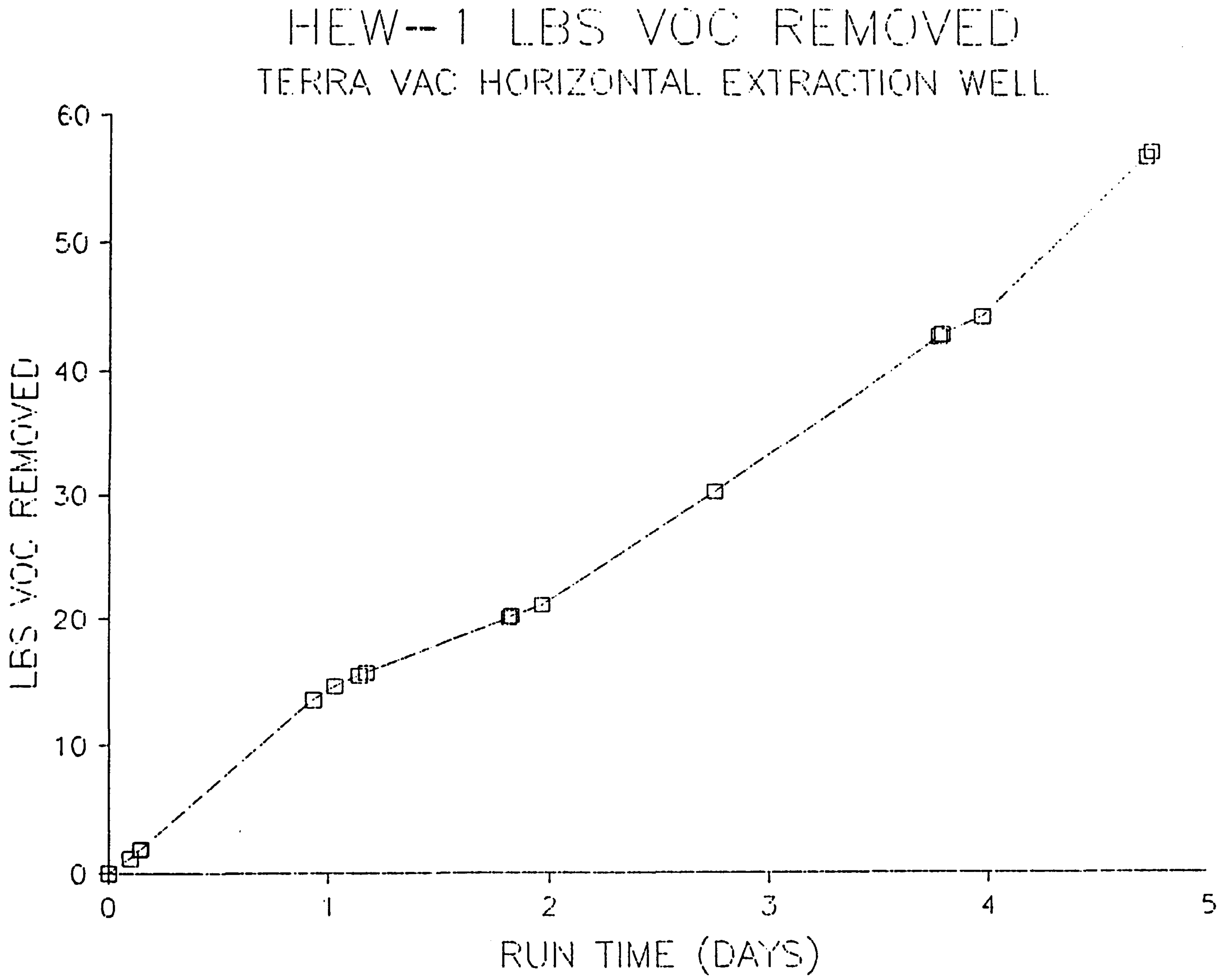
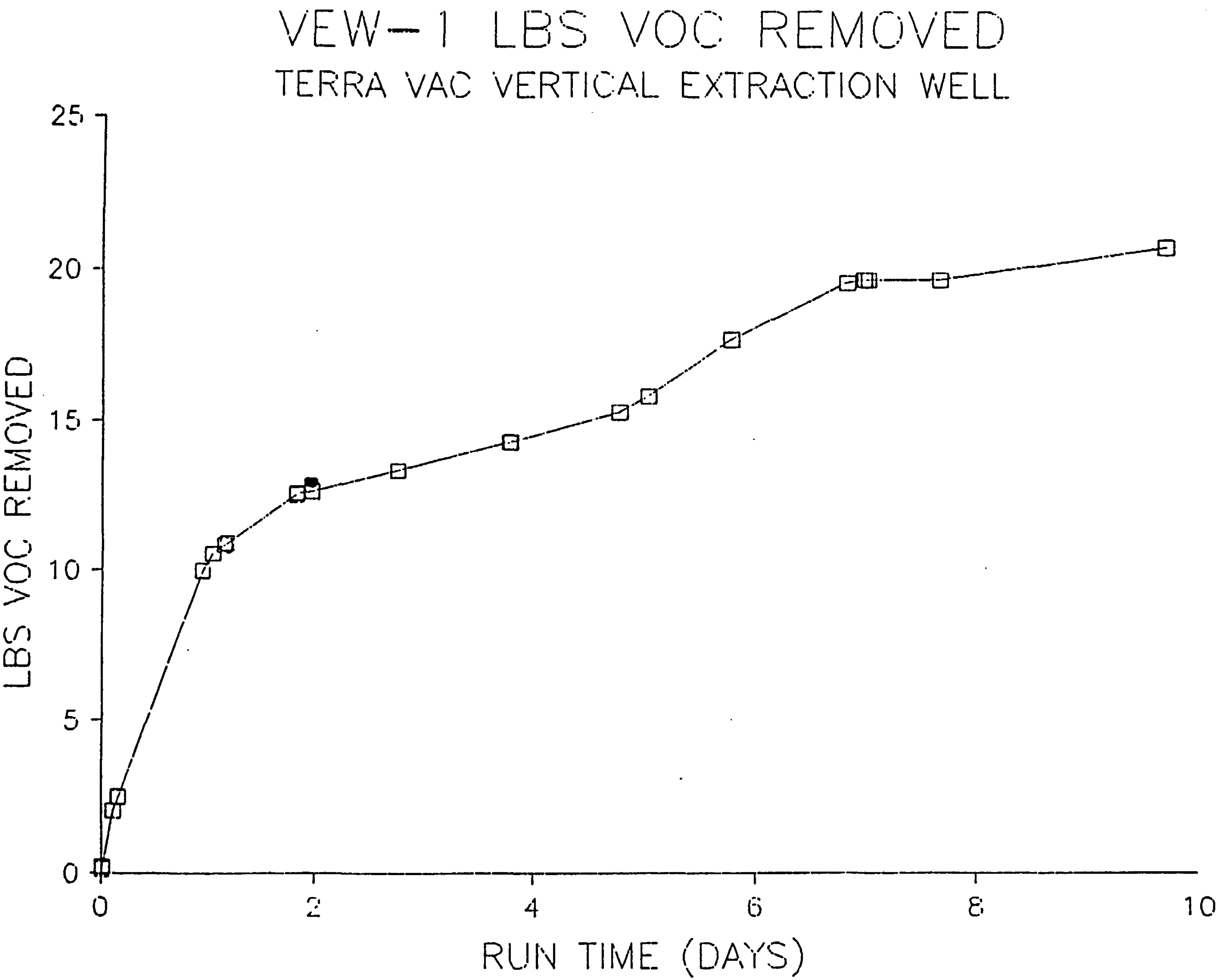

HEW-1 LBS VOC REMOVED
TERRA VAC HORIZONTAL EXTRACTION WELL
LBS VOC REMOVED
RUN TIME (DAYS)
0
10
20
30
40
50
60
0
1
2
3
4
5

FIGURE 4



VEW-1 LBS VOC REMOVED
TERRA VAC VERTICAL EXTRACTION WELL
25
20
15
10
5
0
LBS VOC REMOVED
0
2
4
6
8
10
RUN TIME (DAYS)

FIGURE 5

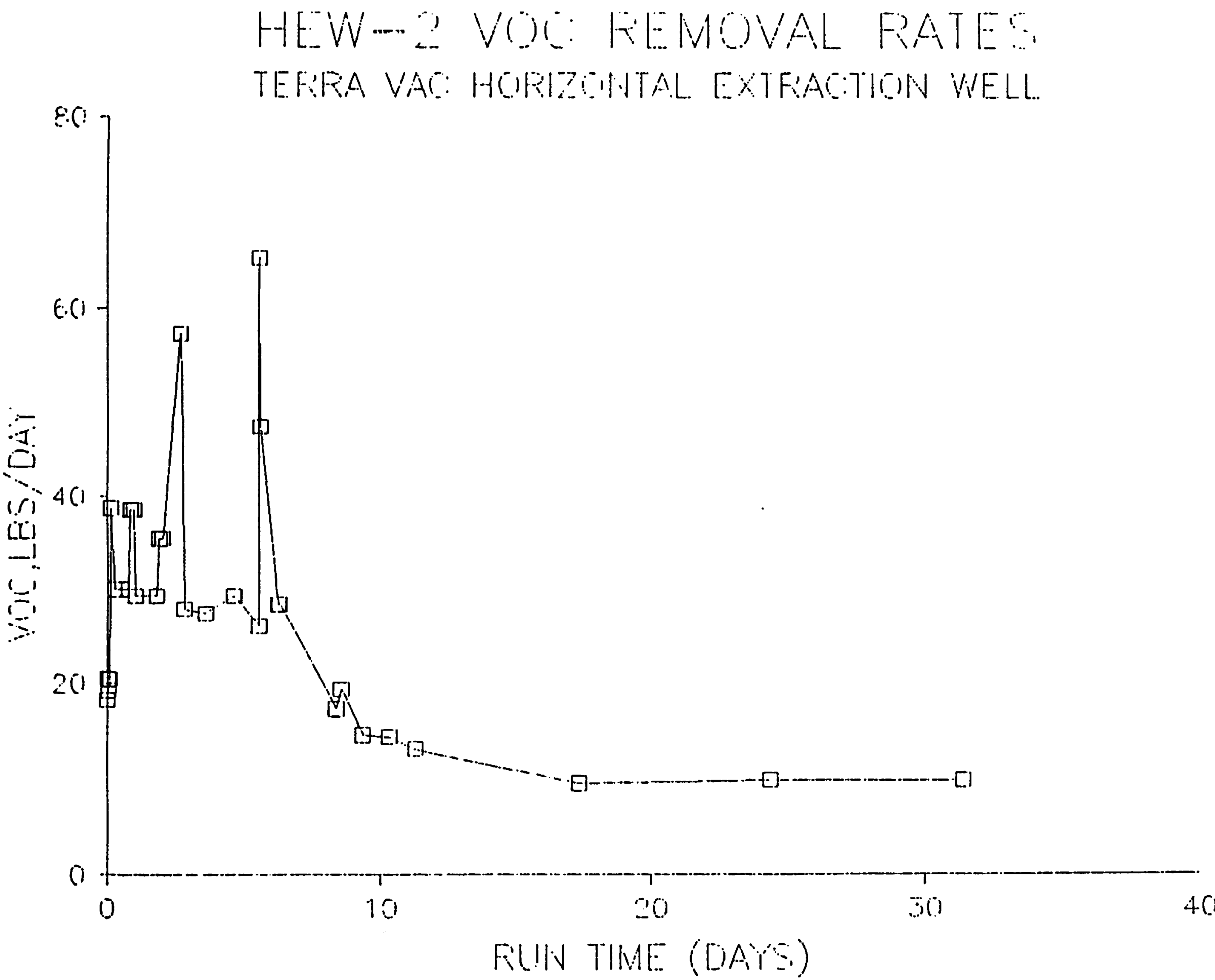

HEW-2 VOC REMOVAL RATES
TERRA VAC HORIZONTAL EXTRACTION WELL
80
60
40
20
0
VOC, LBS/DAY
0
10
20
30
40
RUN TIME (DAYS)

FIGURE 6

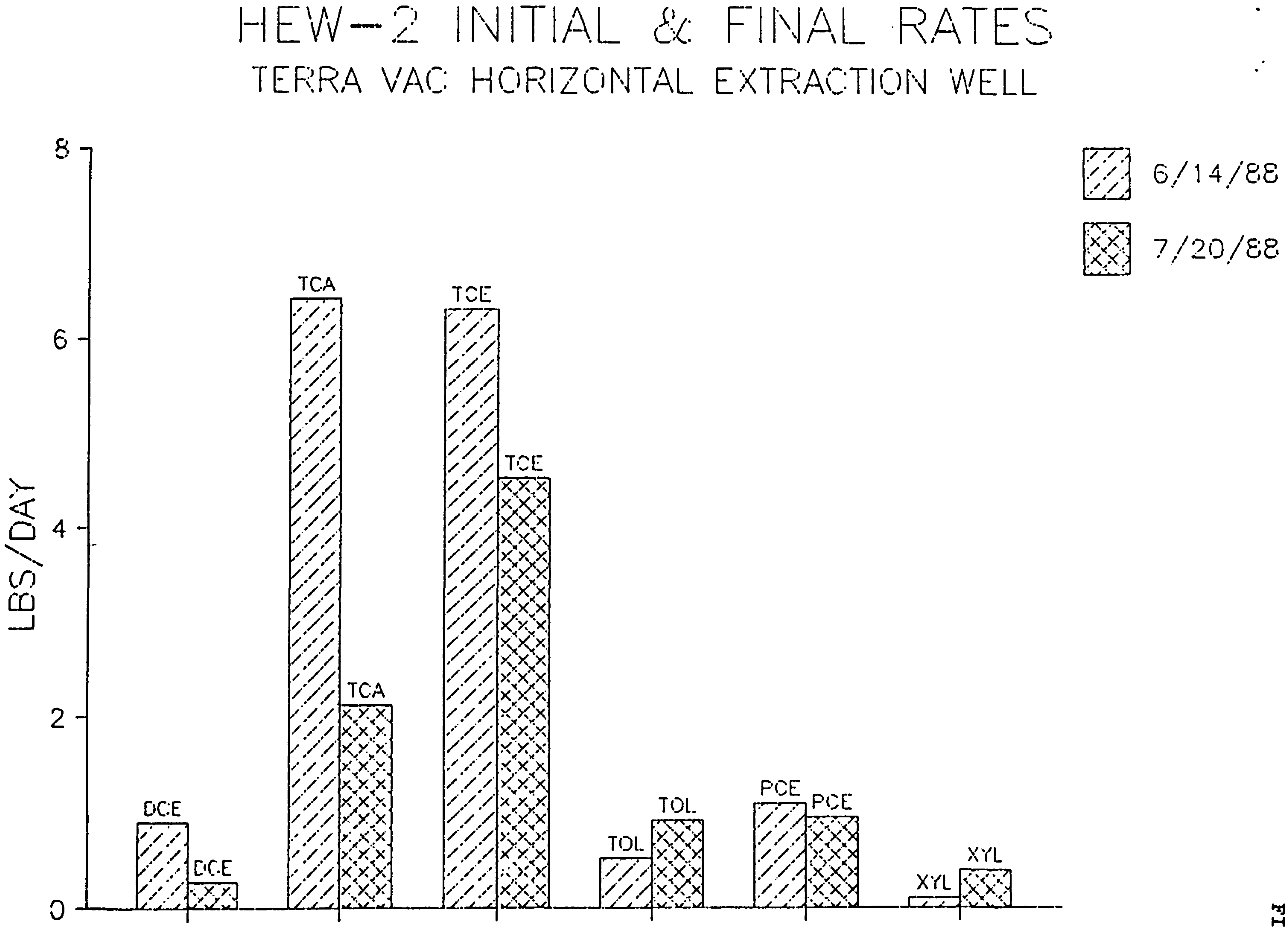

HEW-2 INITIAL & FINAL RATES
TERRA VAC HORIZONTAL EXTRACTION WELL
LBS/DAY
0
2
4
6
8
6/14/88
7/20/88
DCE
DCE
TCA
TCA
TCE
TCE
TOL
TOL
PCE
PCE
XYL
XYL

FIGURE 7

APPENDIX A

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

SUMMARY - ECC VACUUM EXTRACTION PILOT TEST

SAMPLE TIME DATE	HRS	MIN	XX	RUN TIME (DAYS)	X	FLOW RATE (SCFM)	DCE RATE (#/DY)	TCA RATE (#/DY)	TCE RATE (#/DY)	TOL RATE (#/DY)	PCE RATE (#/DY)	XYL RATE (#/DY)	OTHER RATE (#/DY)	T.VOC RATE (#/DY)	CUM VOC (LBS)
14-Jun	12	17	XX	.00	X	0	0	0	0						0
14-Jun	12	18	XX	.00	X	4	.9	6.4	6.3	.5	1.1	.1	2.9	18.2	
14-Jun	12	38	XX	.01	X	4	.8	10.4	4.7	.7	.7	.1	3.0	20.5	
14-Jun	13	18	XX	.04	X	4	.9	10.3	4.3	.7	.9	.2	1.9	19.2	1
14-Jun	13	31	XX	.05	X	4									1
14-Jun	14	31	XX	.05	X	4									1
14-Jun	15	31	XX	.09	X	4	.7	11.5	4.7	.9	.9	.2	1.5	20.4	1
14-Jun	15	40	XX	.10	X	4									2
14-Jun	16	29	XX	.10	X	4									2
14-Jun	17	29	XX	.14	X	8	1.1	20.7	9.7	1.9	2.1	.6	2.7	38.7	2
14-Jun	20	42	XX	.28	X	8	.8	14.2	8.8	1.6	1.9	.5	2.1	30.1	7
15-Jun	8	39	XX	.77	X	17									22
15-Jun	9	20	XX	.77	X	17									22
15-Jun	11	30	XX	.86	X	17	1.0	15.5	13.4	2.2	3.0	.8	2.6	38.5	24
15-Jun	12	10	XX	.89	X	16								38.5	25
15-Jun	12	23	XX	.90	X	21	3.2	8.0	13.8	.3	1.4		.7	66.1	25
15-Jun	12	27	XX	.90	X	23	.8	2.9	1.5	.1	2.1		1.5	75.1	25
15-Jun	14	50	XX	1.00	X	38	1.3	9.4	5.3	1.0	4.1	.4	2.7	62.8	32
15-Jun	15	55	XX	1.05	X	41	.8	11.3	10.6	1.7	2.4	.5	2.1	53.6	35
15-Jun	16	2	XX	1.05	X	59								53.6	35
16-Jun	10	48	XX	1.83	X	79								53.6	77
16-Jun	13	6	XX	1.93	X	84	1.6	16.6	15.3	2.5	5.3	.8	3.4	45.5	82
16-Jun	15	45	XX	2.04	X	86								45.5	87
16-Jun	16	30	XX	2.07	X	98								45.5	88
16-Jun	19	15	XX	2.07	X	121									88
17-Jun	10	45	XX	2.72	X	191	2.9	23.5	24.4	3.2	8.6	1.0	12.3	75.9	113
17-Jun	11	0	XX	2.73	X	0	1.1	6.3	3.6	.5	3.4	1.0	12.3	75.9	114
17-Jun	11	40	XX	2.73	X	0									114
17-Jun	15	0	XX	2.87	X	202	.7	14.2	14.2	2.1	6.7	.6	3.4	41.9	116

A 2

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

SUMMARY - ECC VACUUM EXTRACTION PILOT TEST

SAMPLE TIME			XX		X										
			XX	RUN	X	FLOW	DCE	TCA	TCE	TOL	PCE	XYL	OTHER	T.VOC	CUM
			XX	TIME	X	RATE	RATE	RATE	RATE	RATE	RATE	RATE	RATE	RATE	VOC
DATE	HRS	MIN	XX	(DAYS)	X	(SCFM)	(#/DY)	(#/DY)	(#/DY)	(#/DY)	(#/DY)	(#/DY)	(#/DY)	(#/DY)	(LBS)
18-Jun	10	0	XX	3.66	X	240	1.2	12.1	13.7	2.1	6.0	.8	2.3	38.3	148
19-Jun	10	30	XX	4.68	X	321	.9	12.8	14.8	2.1	6.9	.8	6.3	44.6	191
19-Jun	10	47	XX	4.69	X	0	.4	5.4	2.6	.4	3.9	.8	6.3	44.6	191
19-Jun	11	40	XX	4.69	X	0									191
20-Jun	9	20	XX	5.59	X	210		5.6	10.5	1.6	2.6	.6	5.2	26.1	203
20-Jun	9	50	XX	5.61	X	0						.6	5.2	26.1	203
20-Jun	10	35	XX	5.61	X	0									203
20-Jun	15	0	XX	5.61	X	141	.5	5.9	2.7	.4	4.9	.1	.5	15.1	205
21-Jun	9	0	XX	5.61	X	185	.4	6.5	3.1	.5	5.7	.2	1.4	17.8	217
21-Jun	9	33	XX	5.61	X	0								17.8	218
21-Jun	10	30	XX	5.61	X	0									218
22-Jun	10	0	XX	5.61	X	4	.1	.7	.9	.1	.1		.1	2.0	219
22-Jun	16	10	XX	5.61	X	4	.1	.8	.9	.1	.2		.2	2.2	219
23-Jun	10	0	XX	5.78	X	4	.1	1.1	1.1	.1	.2		.3	2.9	221
24-Jun	11	0	XX	6.82	X	4		.3	.3				.1	.7	223
24-Jun	14	30	XX	6.97	X	5		.3	.3				.1	.7	223
24-Jun	16	34	XX	6.97	X	4									223
24-Jun	16	50	XX	6.98	X	209	1.3	26.6	18.9	3.2	5.6	1.4	8.3	65.2	223
24-Jun	17	35	XX	7.01	X	209	1.0	17.5	16.1	2.7	4.6	1.1	4.5	47.4	225
25-Jun	9	15	XX	7.66	X	237	.6	7.0	10.9	1.6	2.5	.6	5.3	28.4	250
25-Jun	10	30	XX	7.66	X	237	.6	7.0	10.9	1.6	2.5	.6	5.3	28.4	251
27-Jun	11	30	XX	9.70	X	319	.4	3.8	8.1	1.6	1.8	.5	2.1	18.3	299
27-Jun	11	45	XX	9.71	X	319	.4	3.4	7.8	1.5	1.8	.5	2.0	18.3	299
27-Jun	16	0	XX	9.71	X	320	.4	3.3	8.0	1.6	1.8	.5	3.7	19.3	302
28-Jun	10	35	XX	9.71	X	322	.3	2.8	6.7	1.4	1.6	.5	1.3	14.5	315
29-Jun	10	0	XX	10.34	X	324	.3	2.6	6.1	1.3	1.5	.5	2.1	14.3	330
30-Jun	9	15	XX	11.31	X	327	.3	2.4	5.6	1.1	1.3	.4	2.0	13.1	343
06-Jul	11	0	XX	17.38	X	362	.3	2.2	4.6	.8	.8	.3	.5	9.5	412
13-Jul	11	0	XX	24.38	X	347	.3	2.1	4.5	.9	1.0	.4	.7	9.9	479
20-Jul	10	40	XX	31.37	X	346								9.9	548

A 3

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

SAMPLE TIME			XX	HORIZONTAL EXTRACTION WELL - HEW-2		<<< OPERATING SUMMARY					>>>			HEW-2	
DATE	HRS	MIN	XX	RUN TIME (DYS)	FLOW RATE (SCFM)	TOTAL VOC (mg/l)	DCE RATE (#/DY)	TCA RATE (#/DY)	TCE RATE (#/DY)	TOL RATE (#/DY)	PCE RATE (#/DY)	XYL RATE (#/DY)	OTHER RATE (#/DY)	T.VOC RATE (#/DY)	CUM VOC (LBS)
14-Jun	12	17	XX		0										0
14-Jun	12	18	XX		4	49.9	.9	6.4	6.3	.5	1.1	.1	2.9	18.2	
14-Jun	12	38	XX		4	55.9	.8	10.4	4.7	.7	.7	.1	3.0	20.5	.3
14-Jun	13	18	XX		4	52.5	.9	10.3	4.3	.7	.9	.2	1.9	19.2	.8
14-Jun	13	31	XX	.1	4							.2	1.9	19.2	1.0
14-Jun	14	31	XX	.1	4										1.0
14-Jun	15	31	XX	.1	4	52.5	.7	11.5	4.7	.9	.9	.2	1.5	20.4	1.4
14-Jun	15	40	XX	.1	4							.2	1.5	20.4	1.6
14-Jun	16	29	XX	.1	4										1.6
14-Jun	17	29	XX	.1	8	51.1	1.1	20.7	9.7	1.9	2.1	.6	2.7	38.7	2.4
14-Jun	20	42	XX	.3	8	40.1	.8	14.2	8.8	1.6	1.9	.5	2.1	30.1	7.0
15-Jun	8	39	XX	.8	17	51.1	1.1	20.7	9.7	1.9	2.1	.5	2.1	30.1	21.9
15-Jun	9	20	XX	.8	17										21.9
15-Jun	11	30	XX	.9	17	25.7	1.0	15.5	13.4	2.2	3.0	.8	2.6	38.5	23.7
15-Jun	12	10	XX	.9	16									38.5	24.7
15-Jun	12	23	XX	.9	16									38.5	25.1
15-Jun	12	27	XX	.9	17									38.5	25.2
15-Jun	14	50	XX	1.0	17									38.5	29.0
15-Jun	15	55	XX	1.0	17	19.8	.8	11.3	10.6	1.7	2.4	.5	2.1	29.3	30.6
15-Jun	16	2	XX	1.1	25									29.3	30.7
16-Jun	10	48	XX	1.8	33									29.3	53.6
16-Jun	13	6	XX	1.9	38	10.5	1.0	12.8	13.7	2.0	3.0	.6	2.3	35.4	56.7
16-Jun	15	45	XX	2.0	38									35.4	60.7
16-Jun	16	30	XX	2.1	44									35.4	61.8
16-Jun	19	15	XX	2.1	54										61.8
17-Jun	10	45	XX	2.7	106	6.0	1.8	17.2	20.8	2.7	5.3	.9	8.8	57.4	80.3
17-Jun	11	0	XX	2.7	0							.9	8.8	57.4	80.9
17-Jun	11	40	XX	2.7	0										80.9
17-Jun	15	0	XX	2.9	115	2.7		8.9	12.0	1.6	3.1	.4	1.9	27.9	82.8

A4

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

SAMPLE TIME			XX	HORIZONTAL EXTRACTION WELL - HEW-2		<<<	OPERATING SUMMARY				>>>			HEW-2	
DATE	HRS	MIN	XX	RUN TIME (DYS)	FLOW RATE (SCFM)	TOTAL VOC (mg/l)	DCE RATE (#/DY)	TCA RATE (#/DY)	TCE RATE (#/DY)	TOL RATE (#/DY)	PCE RATE (#/DY)	XYL RATE (#/DY)	OTHER RATE (#/DY)	T.VOC RATE (#/DY)	CUM VOC (LBS)
18-Jun	10	0	XX	3.7	146	2.1	.7	7.7	11.7	1.8	3.2	.6	1.7	27.5	104.7
19-Jun	10	30	XX	4.7	202	1.6	.5	7.4	12.2	1.8	2.9	.7	3.9	29.3	133.7
19-Jun	10	47	XX	4.7	0							.7	3.9	29.3	134.0
19-Jun	11	40	XX	4.7	0										134.0
20-Jun	9	20	XX	5.6	210	1.4		5.6	10.5	1.6	2.6	.6	5.2	26.1	145.8
20-Jun	9	50	XX	5.6	0							.6	5.2	26.1	146.4
20-Jun	10	35	XX	5.6	0										146.4
20-Jun	15	0	XX	5.6	0										146.4
21-Jun	9	0	XX	5.6	0										146.4
21-Jun	9	33	XX	5.6	0										146.4
21-Jun	10	30	XX	5.6	0										146.4
22-Jun	10	0	XX	5.6	0										146.4
22-Jun	16	10	XX	5.6	0										146.4
23-Jun	10	0	XX	5.6	0										146.4
24-Jun	11	0	XX	5.6	0										146.4
24-Jun	14	30	XX	5.6	0										146.4
24-Jun	16	34	XX	5.6	0										146.4
24-Jun	16	50	XX	5.6	205	3.6	1.3	26.6	18.9	3.2	5.6	1.4	8.3	65.2	146.7
24-Jun	17	35	XX	5.7	205	2.6	1.0	17.5	16.1	2.7	4.6	1.1	4.5	47.4	148.5
25-Jun	9	15	XX	6.3	233	1.4	.6	7.0	10.9	1.6	2.5	.6	5.3	28.4	173.2
25-Jun	10	30	XX	6.4	233	1.4	.6	7.0	10.9	1.6	2.5	.6	5.3	28.4	174.7
27-Jun	11	30	XX	8.4	315	.6	.4	3.4	7.8	1.5	1.8	.5	2.0	17.3	221.4
27-Jun	11	45	XX	8.4	315	.6	.4	3.4	7.8	1.5	1.8	.5	2.0	17.3	221.5
27-Jun	16	0	XX	8.6	315	.7	.4	3.3	8.0	1.6	1.8	.5	3.7	19.3	224.8
28-Jun	10	35	XX	9.4	318	.5	.3	2.8	6.7	1.4	1.6	.5	1.3	14.5	237.9
29-Jun	10	0	XX	10.3	320	.5	.3	2.6	6.1	1.3	1.5	.5	2.1	14.3	252.0
30-Jun	9	15	XX	11.3	323	.5	.3	2.4	5.6	1.1	1.3	.4	2.0	13.1	265.3
06-Jul	11	0	XX	17.4	357	.3	.3	2.2	4.6	.8	.8	.3	.5	9.5	334.0
13-Jul	11	0	XX	24.4	343	.3	.3	2.1	4.5	.9	1.0	.4	.7	9.9	401.9
20-Jul	10	40	XX	31.4	341									9.9	470.8

A5

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

SAMPLE TIME			XX	HORIZONTAL EXTRACTION WELL - HEW-1										HEW-1	
			XX	<<< OPERATING SUMMARY >>>											
DATE	HRS	MIN	XX	RUN TIME (DYS)	FLOW RATE (SCFM)	TOTAL VOC (mg/l)	DCE RATE (#/DY)	TCA RATE (#/DY)	TCE RATE (#/DY)	TOL RATE (#/DY)	PCE RATE (#/DY)	XYL RATE (#/DY)	OTHER RATE (#/DY)	T.VOC RATE (#/DY)	CUM VOC (LBS)
14-Jun	12	17	XX												
14-Jun	12	18	XX												
14-Jun	12	38	XX												
14-Jun	13	18	XX												
14-Jun	13	31	XX												
14-Jun	14	31	XX												
14-Jun	15	31	XX												
14-Jun	15	40	XX												
14-Jun	16	29	XX												
14-Jun	17	29	XX												
14-Jun	20	42	XX												
15-Jun	8	39	XX												
15-Jun	9	20	XX												
15-Jun	11	30	XX												
15-Jun	12	10	XX												
15-Jun	12	23	XX											.00	
15-Jun	12	27	XX		2	58.74	.8	2.9	1.5	.1	2.1		1.47	8.9	
15-Jun	14	50	XX	.1	17	9.97	.9	5.2	2.3	.7	3.7	.3	1.70	14.8	1.2
15-Jun	15	55	XX	.1	17									14.8	1.9
15-Jun	16	2	XX	.2	25									14.8	1.9
16-Jun	10	48	XX	.9	33									14.8	13.5
16-Jun	13	6	XX	1.0	34	2.50	.5	2.8	1.2	.3	2.1	.1	.62	7.5	14.5
16-Jun	15	45	XX	1.1	34									7.5	15.4
16-Jun	16	30	XX	1.2	39									7.5	15.6
16-Jun	19	15	XX	1.2	52										15.6
17-Jun	10	45	XX	1.8	68	2.23	.8	4.6	1.9	.3	3.0	.1	3.00	13.6	20.0
17-Jun	11	0	XX	1.8		2.23	.8	4.6	1.9	.3	3.0	.1	3.00	13.6	20.1
17-Jun	11	40	XX	1.8											20.1
17-Jun	15	0	XX	2.0	82	1.78	.7	4.9	2.0	.4	3.6	.2	1.44	13.1	21.0

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

			XX	HORIZONTAL EXTRACTION WELL - HEW-1										HEW-1	
SAMPLE TIME			XX			<<<	OPERATING SUMMARY				>>>				
DATE	HRS	MIN	XX	RUN TIME (DYS)	FLOW RATE (SCFM)	TOTAL VOC (mg/l)	DCE RATE (#/DY)	TCA RATE (#/DY)	TCE RATE (#/DY)	TOL RATE (#/DY)	PCE RATE (#/DY)	XYL RATE (#/DY)	OTHER RATE (#/DY)	T.VOC RATE (#/DY)	CUM VOC (LBS)
18-Jun	10	0	XX	2.8	90	1.24	.5	4.1	1.8	.3	2.8	.1	.50	10.0	30.2
19-Jun	10	30	XX	3.8	114	1.40	.4	5.0	2.4	.3	3.9	.1	2.29	14.3	42.6
19-Jun	10	47	XX	3.8		1.40	.4	5.0	2.4	.3	3.9	.1	2.29	14.3	42.7
19-Jun	11	40	XX	3.8											42.7
20-Jun	9	20	XX	3.8											42.7
20-Jun	9	50	XX	3.8											42.7
20-Jun	10	35	XX	3.8											42.7
20-Jun	15	0	XX	4.0	141	1.20	.5	5.9	2.7	.4	4.9	.1	.49	15.1	44.1
21-Jun	9	0	XX	4.7	185	1.08	.4	6.5	3.1	.5	5.7	.2	1.37	17.8	56.5
21-Jun	9	33	XX	4.7										17.8	56.9
21-Jun	10	30	XX	4.7											56.9
22-Jun	10	0	XX	4.7											56.9
22-Jun	16	10	XX	4.7											56.9
23-Jun	10	0	XX	4.7											56.9
24-Jun	11	0	XX	4.7											56.9
24-Jun	14	30	XX	4.7											56.9
24-Jun	16	34	XX	4.7											56.9
24-Jun	16	50	XX	4.7											56.9
24-Jun	17	35	XX	4.7											56.9
25-Jun	9	15	XX	4.7											56.9
25-Jun	10	30	XX	4.7											56.9
27-Jun	11	30	XX	4.7											56.9
27-Jun	11	45	XX	4.7											56.9
27-Jun	16	0	XX	4.7											56.9
28-Jun	10	35	XX	4.7											56.9
29-Jun	10	0	XX	4.7											56.9
30-Jun	9	15	XX	4.7											56.9
06-Jul	11	0	XX	4.7											56.9
13-Jul	11	0	XX	4.7											56.9
20-Jul	10	40	XX	4.7											56.9

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

SAMPLE TIME			XX	VERTICAL EXTRACTION WELL - VE-1		<<< OPERATING SUMMARY >>>								VE-1	
DATE	HRS	MIN	XX	RUN TIME (DYS)	FLOW RATE (SCFM)	TOTAL VOC (mg/l)	DCE RATE (#/DY)	TCA RATE (#/DY)	TCE RATE (#/DY)	TOL RATE (#/DY)	PCE RATE (#/DY)	XYL RATE (#/DY)	OTHER RATE (#/DY)	T.VOC RATE (#/DY)	CUM VOC (LBS)
14-Jun	12	17	XX												
14-Jun	12	18	XX												
14-Jun	12	38	XX												
14-Jun	13	18	XX												
14-Jun	13	31	XX												
14-Jun	14	31	XX												
14-Jun	15	31	XX												
14-Jun	15	40	XX												
14-Jun	16	29	XX												
14-Jun	17	29	XX												
14-Jun	20	42	XX												
15-Jun	8	39	XX												.00
15-Jun	9	20	XX												
15-Jun	11	30	XX												
15-Jun	12	10	XX												
15-Jun	12	23	XX		4	73.67	3.2	8.0	13.8	.3	1.4		.7	27.6	.1
15-Jun	12	27	XX		4									27.6	.2
15-Jun	14	50	XX	.1	4	25.36	.4	4.2	3.0	.4	.4	.1	1.0	9.5	2.0
15-Jun	15	55	XX	.2	8									9.5	2.5
15-Jun	16	2	XX	.2	8									9.5	2.5
16-Jun	10	48	XX	.9	13									9.5	10.0
16-Jun	13	6	XX	1.0	13	2.18	.1	1.0	.5	.3	.1		.5	2.5	10.5
16-Jun	15	45	XX	1.1	15									2.5	10.8
16-Jun	16	30	XX	1.2	15									2.5	10.9
16-Jun	19	15	XX	1.2	15										10.9
17-Jun	10	45	XX	1.8	17	3.31	.3	1.7	1.7	.3	.3	.1	.5	5.0	12.5
17-Jun	11	0	XX	1.8		3.31	.3	1.7	1.7	.3	.3	.1	.5	5.0	12.5
17-Jun	11	40	XX	1.8											12.5
17-Jun	15	0	XX	2.0	4	2.53	.1	.4	.2	.1			.1	.9	12.6

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

SAMPLE TIME			XX	VERTICAL EXTRACTION WELL - VE-1										VE-1	
			XX	‹‹‹ OPERATING SUMMARY ›››											
DATE	HRS	MIN	XX	RUN TIME (DYS)	FLOW RATE (SCFM)	TOTAL VOC (mg/l)	DCE RATE (#/DY)	TCA RATE (#/DY)	TCE RATE (#/DY)	TOL RATE (#/DY)	PCE RATE (#/DY)	XYL RATE (#/DY)	OTHER RATE (#/DY)	T.VOC RATE (#/DY)	CUM VOC (LBS)
18-Jun	10	0	XX	2.8	4	2.21	.1	.4	.2	.1			.1	.9	13.3
19-Jun	10	30	XX	3.8	4	2.55		.4	.3	.1			.1	1.0	14.3
19-Jun	10	47	XX	3.8		2.55		.4	.3	.1			.1	1.0	14.3
19-Jun	11	40	XX	3.8											14.3
20-Jun	9	20	XX	3.8											14.3
20-Jun	9	50	XX	3.8											14.3
20-Jun	10	35	XX	3.8											14.3
20-Jun	15	0	XX	3.8											14.3
21-Jun	9	0	XX	3.8											14.3
21-Jun	9	33	XX	3.8											14.3
21-Jun	10	30	XX	3.8											14.3
22-Jun	10	0	XX	4.8	4	6.35	.1	.7	.9	.1	.1		.1	2.0	15.3
22-Jun	16	10	XX	5.0	4	6.78	.1	.8	.9	.1	.2		.2	2.2	15.8
23-Jun	10	0	XX	5.8	4	8.89	.1	1.1	1.1	.1	.2		.3	2.9	17.7
24-Jun	11	0	XX	6.8	4	2.10		.3	.3				.1	.7	19.5
24-Jun	14	30	XX	7.0	5	2.10		.3	.3				.1	.7	19.6
24-Jun	16	34	XX	7.0	4										19.6
24-Jun	16	50	XX	7.0	4										19.6
24-Jun	17	35	XX	7.0	4										19.6
25-Jun	9	15	XX	7.7	4										19.6
25-Jun	10	30	XX	7.7	4										19.6
27-Jun	11	30	XX	9.7	4	2.55		.4	.3	.1			.1	1.0	20.7
27-Jun	11	45	XX	9.7	4									1.0	20.7
27-Jun	16	0	XX	9.7	4										20.7
28-Jun	10	35	XX	9.7	4										20.7
29-Jun	10	0	XX	9.7	4										20.7
30-Jun	9	15	XX	9.7	4										20.7
06-Jul	11	0	XX	9.7	4										20.7
13-Jul	11	0	XX	9.7	4										20.7
20-Jul	10	40	XX	9.7	4										20.7

APPENDIX B

TERRA VAC/ ECC - EKN SITE / PROJECT 88-304

HORIZONTAL EXTRACTION WELL - HEW-2

SAMPLE TIME			((OPERATION DATA))					((GAS CHROMATOGRAPH READOUT)) HEW-2							((WELLHEAD CONCENTRATION)) HEW-2						
DATE	HRS	MIN	SAMP NUM	INJ VOL (ul)	WELL VAC ("Hg)	FLOW RATE (SCFM)	FLOW RATE (ACFM)	1,1 DCE (mg/l)	1,1,1 TCA (mg/l)	TCE (mg/l)	TOL (mg/l)	PCE (mg/l)	M,P-XYL (mg/l)	TOTAL AREA 1000X	1.1 DCE (mg/l)	1,1,1 TCA (mg/l)	TCE (mg/l)	TOL (mg/l)	PCE (mg/l)	M,P-XYL (mg/l)	OTHER (mg/l)
14-Jun	12	17	777											0							
14-Jun	12	18	106	100	10.0	4	5	.163	1.170	1.150	.094	.200	.019	1020	2.445	17.55	17.25	1.430	3.000	.285	7.92
14-Jun	12	38	107	100	10.0	4	5	.146	1.890	.863	.121	.109	.024	1105	2.190	28.35	12.95	1.815	1.955	.360	8.27
14-Jun	13	18	108	100	10.0	4	5	.162	1.870	.791	.129	.132	.031	930	2.430	28.05	11.67	1.935	2.445	.465	5.31
14-Jun	13	31	999	100	10.0	4	5														
14-Jun	14	31	777	100	10.0	4	5														
14-Jun	15	31	109	100	7.5	4	5	.128	2.216	.903	.171	.131	.048	990	1.707	29.55	12.04	2.250	2.387	.640	3.94
14-Jun	15	40	999	100	8.0	4	5														
14-Jun	16	29	777	100	9.0	4	5														
14-Jun	17	29	110	100	8.5	8	10	.103	1.953	.915	.182	.138	.057	928	1.437	27.25	12.77	2.540	2.721	.795	3.55
14-Jun	20	42	111	100	9.0	8	10	.077	1.328	.823	.152	.150	.051	728	1.100	18.97	11.76	2.171	2.566	.729	2.78
15-Jun	8	39	999	100	9.3	17	20														
15-Jun	9	20	777	100	9.0	17	20														
15-Jun	11	30	112	100	9.0	17	20	.046	.724	.626	.104	.104	.036	475	.657	10.34	8.94	1.486	2.000	.514	1.76
15-Jun	12	10	888	100	10.0	16	20														
15-Jun	12	23	888	100	10.0	16	20														
15-Jun	12	27	666	100	9.0	17	20														
15-Jun	14	50	666	100	8.5	17	20														
15-Jun	15	55	117	100	9.5	17	20	.036	.520	.491	.077	.084	.025	358	.527	7.610	7.185	1.127	1.555	.366	1.39
15-Jun	16	2	888	100	8.5	25	30														
16-Jun	10	46	888	100	9.0	33	40														
16-Jun	13	6	120	100	9.1	38	45	.020	.266	.283	.042	.051	.012	191	.287	3.818	4.062	.603	.904	.172	.66
16-Jun	15	45	888	100	9.0	38	45														
16-Jun	16	30	999	100	1.0	44	45														
16-Jun	19	15	777	100	12.0	54	70														
17-Jun	10	45	125	100	7.8	106	123	.014	.134	.162	.021	.034	.007	143	.189	1.811	2.169	.284	.554	.095	.53
17-Jun	11	0	999	100	1.0	0															
17-Jun	11	40	777	100	1.0	0															
17-Jun	15	0	129	100	9.0	115	138	ND	.060	.081	.011	.018	.003	50		.857	1.157	.157	.300	.043	.18

TERRA VAC/ ECC - EEM SITE / PROJECT 88-304

SAMPLE TIME			HORIZONTAL EXTRACTION WELL - HEW-2													HEW-2						
			<< OPERATION DATA >>					<< GAS CHROMATOGRAPH READOUT >>							<< WELLHEAD CONCENTRATION >>							
DATE	HRS	MIN	SAMP NUM	INJ VOL (ul)	WELL VAC ("Hg)	FLOW RATE (SCFM)	FLOW RATE (ACFM)	1,1 DCE (ug/l)	1,1,1 TCA (ug/l)	TCE (ug/l)	TOL (ug/l)	PCE (ug/l)	M,P-XYL (ug/l)	TOTAL AREA 1000X	1,1 DCE (ug/l)	1,1,1 TCA (ug/l)	TCE (ug/l)	TOL (ug/l)	PCE (ug/l)	M,P-XYL (ug/l)	OTHER (ug/l)
18-Jun	10	0	133	500	6.3	146	164	.021	.232	.354	.054	.079	.019	223	.053	.587	.856	.137	.248	.048	.13
19-Jun	10	30	136	500	5.8	202	225	.012	.164	.271	.039	.050	.015	199	.030	.407	.672	.097	.161	.037	.21
19-Jun	10	47	999	100	1.0	0															
19-Jun	11	40	777	100	1.0	0															
20-Jun	9	20	137	500	7.0	210	240	nd	.115	.214	.032	.040	.012	168		.300	.558	.083	.136	.031	.28
20-Jun	9	50	999	100	1.0	0															
20-Jun	10	35		100	1.0	0															
20-Jun	15	0		100	1.0	0															
21-Jun	9	0		100	1.0	0															
21-Jun	9	33		100	1.0	0															
21-Jun	10	30		100	1.0	0															
22-Jun	10	0		100	1.0	0															
22-Jun	16	10		100	1.0	0															
23-Jun	10	0		100	1.0	0															
24-Jun	11	0		100	1.0	0															
24-Jun	14	30		100	1.0	0															
24-Jun	16	34	777	100	1.0	0															
24-Jun	16	50	155	500	7.2	205	235	.027	.551	.391	.067	.087	.028	377	.071	1.450	1.029	.176	.303	.074	.45
24-Jun	17	35	156	500	7.2	205	235	.020	.362	.333	.055	.072	.023	259	.053	.953	.676	.145	.250	.061	.25
25-Jun	9	15	157	500	5.9	233	260	.011	.135	.209	.030	.037	.012	164	.027	.336	.520	.075	.122	.029	.25
25-Jun	10	30	157	500	5.9	233	260	.011	.135	.209	.030	.037	.012	164	.027	.336	.520	.075	.122	.029	.25
27-Jun	11	30	159	500	4.3	315	340	.006	.051	.118	.023	.020	.007	78	.014	.119	.275	.054	.063	.016	.07
27-Jun	11	45	159	500	4.3	315	340	.006	.051	.118	.023	.020	.007	78	.014	.119	.275	.054	.063	.016	.07
27-Jun	16	0	161	1000	4.2	315	340	.012	.101	.244	.048	.040	.016	157	.014	.117	.264	.056	.065	.019	.13
28-Jun	10	35	162	1000	3.8	318	340	.010	.067	.205	.042	.036	.014	127	.011	.099	.235	.048	.057	.016	.05
29-Jun	10	0	163	1000	3.5	320	340	.009	.081	.188	.039	.033	.014	139	.010	.092	.213	.044	.053	.016	.07
30-Jun	9	15	164	1000	3.0	323	340	.008	.074	.173	.035	.030	.012	130	.009	.082	.192	.039	.047	.013	.07
06-Jul	11	0	171	1000	2.0	357	370	.010	.068	.145	.024	.025	.010	54	.010	.068	.145	.024	.025	.010	.02
13-Jul	11	0	172	1000	2.0	343	355	.009	.069	.147	.030	.031	.013	52	.009	.069	.147	.030	.031	.013	.02
20-Jul	10	40	999	1000	2.3	341	355														

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

SAMPLE TIME			HORIZONTAL EXTRACTION WELL - HEW-1 ((OPERATION DATA))					HEW-1 ((GAS CHROMATOGRAPH READOUT))							HEW-1 ((WELLHEAD CONCENTRATION))						
				INJ	WELL	FLOW	FLOW	1,1	1,1,1				N.F-	TOTAL	1,1	1,1,1				N.F-	
			SAMP	VOL	VAC	RATE	RATE	DCE	TCA	TCE	TOL	PCE	XTL	AREA	DCE	TCA	TCE	TOL	PCE	XTL	OTHER
DATE	HRS	MIN	NUM	(ml)	("Hg)	(SCFM)	(ACFM)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	1000X	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
14-Jun	12	17																			
14-Jun	12	18		100	1.0																
14-Jun	12	38		100	1.0																
14-Jun	13	18		100	1.0																
14-Jun	13	31		100	1.0																
14-Jun	14	31		100	1.0																
14-Jun	15	31		100	1.0																
14-Jun	15	40		100	1.0																
14-Jun	16	29		100	1.0																
14-Jun	17	29		100	1.0																
14-Jun	20	42		100	1.0																
15-Jun	8	39		100	1.0																
15-Jun	9	20		100	1.0																
15-Jun	11	30		100	1.0																
15-Jun	12	10		100	1.0																
15-Jun	12	23	777	100	1.0																
15-Jun	12	27	114	100	8.5	2	2	.377	1.360	.701	.034	1.015	.008	1210	5.26	15.26	9.76	.47	14.16	.11	9.70
15-Jun	14	50	115	100	9.5	17	20	.040	.241	.107	.030	.170	.015	154	.59	3.53	1.57	.44	2.49	.22	1.15
15-Jun	15	55	666	100	9.5	17	20														
15-Jun	16	2	888	100	9.5	25	30														
16-Jun	10	48	888	100	9.5	33	40														
16-Jun	13	6	122	100	8.8	34	40	.012	.065	.027	.006	.049	.003	44	.17	.52	.38	.08	.69	.04	.20
16-Jun	15	45	888	100	8.8	34	40														
16-Jun	16	30	999	100	1.0	39	40														
16-Jun	19	15	777	100	1.0	52	53														
17-Jun	10	45	124	100	6.4	66	80	.009	.054	.022	.003	.036	.001	54	.13	.75	.31	.04	.50	.01	.49
17-Jun	11	6	999	100	1.0																
17-Jun	11	40	777	100	1.0																
17-Jun	15	0	127	500	9.7	82	100	.031	.227	.050	.018	.163	.007	158	.09	.67	.27	.05	.48	.02	.20

TERRA VAC/ ECC - ERM SITE / PROJECT 88-304

HORIZONTAL EXTRACTION WELL - HEW-1

SAMPLE TIME DATE	HRS	MIN	<< OPERATION DATA >> SAMP NUM	INJ VOL (ml)	WELL VAC ("Hg)	FLOW RATE (SCFM)	FLOW RATE (ACFM)	HEW-1 << GAS CHROMATOGRAPH READOUT >> 1,1 DCE (mg/l)	1,1,1 TCA (mg/l)	TCE (mg/l)	TOL (mg/l)	PCE (mg/l)	M,P-XYL (mg/l)	TOTAL AREA 1000X	HEW-1 << WELLHEAD CONCENTRATION >> 1.1 DCE (mg/l)	1,1,1 TCA (mg/l)	TCE (mg/l)	TOL (mg/l)	PCE (mg/l)	M,P-XYL (mg/l)	OTHER (mg/l)
18-Jun	10	0	131	500	7.2	90	103	.022	.152	.085	.013	.130	.005	102	.06	.51	.22	.03	.34	.01	.06
19-Jun	10	30	134	500	6.8	114	130	.014	.187	.090	.012	.147	.004	152	.04	.48	.23	.03	.38	.01	.22
19-Jun	10	47	999	100	1.0																
19-Jun	11	40		100	1.0																
20-Jun	9	20		100	1.0																
20-Jun	9	50		100	1.0																
20-Jun	10	35	777	100	1.0																
20-Jun	15	0	138	500	9.5	141	170	.013	.161	.074	.011	.133	.004	78	.04	.47	.22	.03	.39	.01	.04
21-Jun	9	0	139	1000	7.8	165	215	.020	.251	.138	.023	.255	.009	179	.03	.39	.19	.03	.34	.01	.08
21-Jun	9	33	999	100	1.0																
21-Jun	10	30		100	1.0																
22-Jun	10	0		100	1.0																
22-Jun	16	10		100	1.0																
23-Jun	10	0		100	1.0																
24-Jun	11	0		100	1.0																
24-Jun	14	30		100	1.0																
24-Jun	16	34		100	1.0																
24-Jun	16	50		100	1.0																
24-Jun	17	35		100	1.0																
25-Jun	9	15		100	1.0																
25-Jun	10	30		100	1.0																
27-Jun	11	30		100	1.0																
27-Jun	11	45		100	1.0																
27-Jun	16	0		100	1.0																
28-Jun	10	35		100	1.0																
29-Jun	10	6		100	1.0																
30-Jun	9	15		100	1.0																
06-Jul	11	0		100	1.0																
13-Jul	11	0		100	1.0																
20-Jul	10	40		100	1.0																

TERRA VAC/ ECC - EEN SITE / PROJECT 88 - 304

SAMPLE TIME DATE	HRS	MIN	II	SAMP NUM	INJ VOL (ul)	WELL VAC ("Hg)	FLOW RATE (SCFM)	FLOW RATE (ACFM)	GC 1,1 DCE (ng/l)	GC 1,1,1 TCA (ng/l)	GC TCE (ng/l)	GC TOL (ng/l)	GC PCE (ng/l)	GC M,P-XYL (ng/l)	GC TOTAL AREA 1000X	WH 1,1 DCE (ng/l)	WH 1,1,1 TCA (ng/l)	WH TCE (ng/l)	WH TOL (ng/l)	WH PCE (ng/l)	WH M,P-XYL (ng/l)	WH OTHER (ng/l)
			II	VERTICAL EXTRACTION WELL - VE-1												VERTICAL EXTRACTION WELL - VE-1						
			II	<< OPERATION DATA >>					<< GAS CHROMATOGRAPH READOUT >>							<< WELLHEAD CONCENTRATION >>						
14-Jun	12	17	II												0							
14-Jun	12	18	II		100	1.0									0							
14-Jun	12	36	II		100	1.0									0							
14-Jun	13	16	II		100	1.0									0							
14-Jun	13	31	II		100	1.0									0							
14-Jun	14	31	II		100	1.0									0							
14-Jun	15	31	II		100	1.0									0							
14-Jun	15	46	II		100	1.0									0							
14-Jun	16	29	II		100	1.0									0							
14-Jun	17	29	II		100	1.0									0							
14-Jun	20	42	II		100	1.0									0							
15-Jun	8	39	II		100	1.0									0							
15-Jun	9	20	II		100	1.0									0							
15-Jun	11	30	II		100	1.0									0							
15-Jun	12	10	II	777	100	8.8									0							
15-Jun	12	23	II	113	100	9.0	4	5	.606	1.501	2.544	.059	.267	.007	1049	8.657	21.44	36.91	.843	3.814	.100	1.89
15-Jun	12	27	II	888	100	8.8	4	5														
15-Jun	14	50	II	116	100	9.0	4	5	.078	.782	.558	.072	.082	.020	490	1.114	11.17	7.97	1.029	1.171	.286	2.62
15-Jun	15	55	II	666	100	9.0	8	10														
15-Jun	16	2	II	666	100	9.0	8	10														
16-Jun	10	46	II	888	100	8.5	13	15														
16-Jun	13	6	II	121	100	8.0	13	15	.008	.065	.030	.016	.008	.003	61	.109	.89	.41	.216	.109	.041	.40
16-Jun	15	45	II	888	100	1.0	15	15														
16-Jun	16	30	II	999	100	1.0	15	15														
16-Jun	19	15	II	777	100	1.0	15	15														
17-Jun	10	45	II	126	100	6.6	17	20	.016	.081	.082	.012	.015	.003	68	.226	1.15	1.16	.170	.212	.042	.36
17-Jun	11	0	II	999	100	1.0																
17-Jun	11	40	II	777	100	1.0																
17-Jun	15	8	II	128	500	10.0	4	5	.053	.339	.213	.070	.041	.017	280	.159	1.02	.64	.210	.123	.051	.33

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TERRA VAC/ ECC - ERN SITE / PROJECT 88 - 304

SAMPLE TIME			II	VERTICAL EXTRACTION WELL - VE-1																					
			II	<< OPERATION DATA >>					||	<< GAS CHROMATOGRAPH READOUT >>							||	<< WELLHEAD CONCENTRATION >>						
			II	SAMP	INJ VOL	WELL VAC	FLOW RATE	FLOW RATE	||	1,1 DCE	1,1,1 TCA	TCE	TOL	PCE	N.P-ITL	TOTAL AREA	||	1,1 DCE	1,1,1 TCA	TCE	TOL	PCE	N.P-ITL	OTHER
DATE	HRS	MIN	II	NUM	(ul)	("Hg)	(SCFM)	(ACFM)	||	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	1000X	||	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
18-Jun	10	0	II	132	500	7.8	4	5	||	.049	.339	.215	.061	.044	.016	256	||	.132	.92	.58	.165	.119	.043	.25
19-Jun	10	30	II	135	500	7.1	4	5	||	.038	.424	.256	.055	.048	.017	256	||	.100	1.11	.67	.144	.126	.045	.36
19-Jun	10	47	II	999	100	1.0			||								||							
19-Jun	11	40	II		100	1.0			||								||							
20-Jun	9	20	II		100	1.0			||								||							
20-Jun	9	50	II		100	1.0			||								||							
20-Jun	10	35	II		100	1.0			||								||							
20-Jun	15	0	II		100	1.0			||								||							
21-Jun	9	0	II		100	1.0			||								||							
21-Jun	9	33	II		100	1.0			||								||							
21-Jun	10	30	II	777	100	1.0			||								||							
22-Jun	10	0	II	140	500	14.6	4	5	||	.094	.588	.692	.047	.101	.017	364	||	.366	2.29	2.70	.183	.394	.066	.36
22-Jun	16	10	II	145	500	14.4	4	5	||	.081	.663	.690	.057	.124	.022	415	||	.312	2.55	2.65	.219	.477	.085	.48
23-Jun	10	0	II	146	500	14.5	4	5	||	.095	.899	.856	.071	.136	.032	556	||	.368	3.48	3.31	.275	.526	.124	.60
24-Jun	11	0	II	154	500	14.5	4	5	||	.019	.202	.211	.017	.033	.009	135	||	.074	.78	.82	.066	.128	.035	.20
24-Jun	14	30	II	999	500		5	5	||								||							
24-Jun	16	34	II	777	500	10.0	4	5	||								||							
24-Jun	16	50	II	888	500	8.7	4	5	||								||							
24-Jun	17	35	II	888	500	8.9	4	5	||								||							
25-Jun	9	15	II	999	500	8.0	4	5	||								||							
25-Jun	10	30	II	777	500	8.0	4	5	||								||							
27-Jun	11	30	II	160	500	6.8	4	5	||	.026	.437	.290	.069	.041	.036	277	||	.067	1.13	.75	.178	.106	.093	.22
27-Jun	11	45	II	999	500	6.8	4	5	||								||							
27-Jun	16	0	II		500	6.8	4	5	||								||							
28-Jun	10	35	II		500	6.8	4	5	||								||							
29-Jun	10	0	II		500	6.8	4	5	||								||							
30-Jun	9	15	II		500	6.8	4	5	||								||							
06-Jul	11	0	II		500	6.8	4	5	||								||							
13-Jul	11	0	II		500	6.8	4	5	||								||							
20-Jul	10	40	II		500	6.8	4	5	||								||							

ATTACHMENT 1

TERRA VAC CORPORATION

Project 88-304

Gas Chromatograph Parameters

I. SCOPE

In order to accurately quantitate Volatile Organic Compound (VOC) content it is necessary to insure peak separation. This is achieved by the use of an appropriate column, with the aid of a temperature program. The parameters for this program are set forth here.

II. EQUIPMENT AND REAGENTS

1. Clean and well lighted work area
2. Temperature progammable gas chromatograph (Shimadzu GC-9A) equipped with a flame ionization detector (FID) and a wide bore capillary column.
3. Nitrogen, carrier gas, zero grade or better
4. Hydrogen, combustion gas, zero grade or better
5. Air, combustion gas, zero grade or better

III. PARAMETERS

1. Initial temperature, 40 C
2. Initial hold, 2 minutes
3. Program rate, 5 C/minute
4. Intermediate temperature, 85 C
5. Intermediate hold, 0.5 minutes
6. Secondary ramp rate,15 C/minute
7. Final temperature,150 C
8. Final hold,3minutes
9. Inlet temperature, 150 C
10. Carrier gas flow, 20 ml/minute
11. Combustion gas flow, Air, 350 ml/minute
12. Combustion gas flow, Hydrogen, 55 ml/minute
13. Detector range, 10*1

IV. PRECAUTIONS

Do not exceed temperature limit of column. Do not operate oven without oven fan operating. Periodically check and clean air filter to electronics. Technician must be fully trained before attempting to operate the gas chromatograph.

ATTACHMENT 2

TERRA VAC CORPORATION

Project 88-304

Integrator Parameters

I. SCOPE

The parameters stated here are normal operating parameters for use with a flame ionization detector (FID). These parameters will require periodic optimization by the operator in order to achieve maximum sensitivity.

II. EQUIPMENT AND REAGENTS

1. Clean and well lighted work area

2. Integrator (Shimadzu C-R3A)

III. PARAMETERS

1. Zero = 0

2. Attenuation (ATTN 2) = 4

3. Chart speed (CHT SP) = 10 mm/min.

4. Area reject (AR REJ) = 250

5. Slope = 300

IV. PRECAUTIONS

It is important that the operator has a full understanding of the instrument in order to achieve optimization. If in doubt about any procedure, refer to the operation manual.

ATTACHMENT 3

TERRA VAC CORPORATION

Project 88-304

Sampling Techniques of Volatile Organic Compounds

I. SCOPE

Volatile Organic Compounds (VOC) are regulated, toxic chemicals and should be treated with care to avoid personal and environmental contamination.

When sampling vapors from the vacuum system it will be considered that the air stream is contaminated with VOC's.

II. EQUIPMENT AND REAGENTS

1. Clean and well lighted work area

2. Hamilton Gastight Syringes 1000ul, 500ul, 250ul sizes

III. PROCEDURE

1. Purge syringe with clean air

2. Insert syringe into well head septum

3. Purge syringe with air stream to be sampled

4. Draw plunger back to desired volume

5. Withdraw needle from wellhead septum and stopper with a septum

6 Log time, location, wellhead vacuum and flow then return sample to GC

IV. PRECAUTIONS

Test syringe before use for leaking plunger and tight needle.

ATTACHMENT 4

TERRA VAC CORPORATION

Project 88-304

Volatile Organic Compounds Standard

I. SCOPE

The purpose of this procedure is to define the standardization of the gas chromatograph for reference in the quantitative analysis of samples containing unknown amounts of Volatile Organic Compounds.

II. EQUIPMENT AND REAGENTS

1. Clean and well lighted work area
2. Gastight syringes 1000ul,250ul,100ul.
3. Pure compounds (CAUTION: Some VOC's are known carcinogens and should be handled with care to avoid possible contamination.)
4. Gas sampling bulb 1000ml size

III. PROCEDURES

Calibration using pure VOC to make gas standard

1. Run a blank of the syringe and 1 liter gas sampling bulb to be used.
2. Inject a known volume of the liquid VOC (or of an equal volume mixture of several compounds of interest) into the 1 liter bulb (verify actual bulb volume beforehand). This is on the order of 1 ul for 100 to 300 ppm levels.
3. Allow the liquid to vaporize and disperse throughout the bulb. This may take 5-10 minutes depending on volatility of the compounds. See precautions.
4. Using a gastight syringe, withdraw a 100-1000ul sample from the bulb and inject it into the GC. Volume utilized should approximate expected field concentrations.
5. Calculation of concentration:

$$mg/L = \frac{sp.gravity*liq.vol*\%purity*inj.volume(ul)}{bulb\ volume * 100\% *1000ul}$$

6. If not within 10% of previous calibration,repeat 4&5. Otherwise maintain calibration values established.

7. Calibrate to new values when repeatability is shown. See precautions.

IV <u>PRECAUTIONS</u>

1. In injecting headspace vapor from pure compound, care must be taken not to overload the column.

2. A wide change in calibration values indicates that troubleshooting of the system or procedures is necessary.

3. In using a liquid, be sure the volume injected will be well below vapor saturation for the bulb volume used.

4. Examine the bulb for any droplets or condensation that may indicate incomplete vaporization of the liquid. Some warming of the bulb (i.e.,sunlight, rubbing with a cloth, even the GC oven briefly) may hasten the process. The less volatile the compound, the more problem this becomes.

5. Do not rely on the bulb's integrity for more than an hour.

ATTACHMENT 3

ERM-North Central, Inc.

MEMORANDUM

TO: Don Smith - ECC Technical Committee
Jerry Amber - ECC Technical Committee

FROM: Roy O. Ball, ERM-North Central, Inc.

DATE: August 30, 1988

RE: Vapor Extraction Design Criteria and Preliminary Cost Estimate

INTRODUCTION

This report details the design criteria which were derived from the TERRA VAC Pilot Test conducted from June 13, 1988 to July 20, 1988, at the ECC site. Two horizontal and two vertical extractions trenches were constructed. The design criteria described herein were developed from HEW-2, one of the two horizontal extraction trenches.

DESIGN COMPONENTS

The vapor extraction system includes the following cost elements:

1. Site preparation

2. Trench construction

3. Vapor extraction and ground water piping

4. Trench backfill and capping

5. Vapor extraction manifold system

6. Vapor extraction blower, motor and controls, including moisture trap

7. Exhaust vapor treatment

8. Exhaust vapor stack and monitoring system

Each of these elements is discussed in more detail below. The estimated costs for each of these elements are presented on Table 1 and the basis for those costs are presented on Table 2.

SITE PREPARATION

Site preparation includes the following cost items:

- o Verification of security.

- o Minor surface leveling and relocation of moveable objects to simplify vapor extraction layout.

- o Three-phase, 440 volt electrical service to blower motor location.

- o Construction of 20' x 20' concrete pad for blower emission control system.

- o Mobilization of site trailer and minor utilities.

The capital cost for this element is $20,000. The expected operating cost for the first year of operation is $10,000.

TRENCH CONSTRUCTION

Trenches will be constructed to the same cross-section as the Pilot Test, i.e., 1.5 feet in width and 9 feet in depth. Trenches will be dug by a conventional backhoe using a narrow width bucket. The dirt will be placed directly in a lined, light dump truck and/or stockpiled for removal by a front-end loader. The excavated dirt will be placed in windrows on the existing concrete pad for subsequent vapor extraction (Area 3 on the attached Figure). In all, a maximum of 1,800 cubic yards is expected to be excavated. The attached Figure 3 indicates the general layout of the vacuum extraction system. The Area 1 and Area 2 trenches will be 150 feet and 100 feet in length, respectively, with a 35-foot separation. Area 3 will have two trenches 200 feet in length located 80 feet apart extending under the concrete pad.

There is no capital cost for this element. The expected operating cost for the first year of operation is $10,000.

VACUUM EXTRACTION AND GROUND WATER PIPING

The trenches will be excavated to the 9-foot level, with a minimum 1-foot width. A 4-inch slotted PVC pipe will be placed at the 8-foot level to drain off any ground water that may accumulate within the vapor extraction trenches. This pipe will be connected to a 4-inch PVC riser which will be manifolded at the surface and connected to a positive displacement pump, as necessary, for water removal. The vapor extraction pipe will be located at the 6-foot level and will consist of 50 feet each of 6,8 and 10-inch slotted PVC pipe. The pipe size is selected to have a maximum velocity of 40 feet per second (fps) before transition to the next section. The pipe will be connected via a 10-inch riser to the surface for connection to the above ground vacuum manifold.

The capital cost for this element is $70,000. The expected operating cost for the first year of operation is $6,000 (for water removal, if necessary).

TRENCH BACKFILL AND CAPPING

As part of installation of the piping system the ground water and vapor collection pipes will be bedded in washed pea gravel. The trench will be filled to the 5-foot level with pea gravel which will be covered with a 30 mil or greater polyethylene liner. A one-foot thick bentonite seal will be constructed on top of the liner using hydrated bentonite pellets. The trench will be filled to grade (approximately 4 feet) with a cement grout mixture to prevent infiltration of surface water and vacuum breakthrough to the surface. The capital cost for this element is $40,000. The first year operating cost for this element is $12,000.

ABOVE GROUND VACUUM MANIFOLD

Because of the high vapor flow rates, the trench vapors will likely be collected in an above ground manifold. The manifold will be appropriately insulated and will change in size from 1′ x 1.25′ at the start of the manifold system to a nominal 3′ x 3′ at the connection to the blower plenum. The blower plenum will be designed to receive 25,000 SCFM at a nominal 4′ x 4′ size. The surface manifold will be sloped to allow the removal of any condensation which may form.

The capital cost for this element is $15,000. The expected operating cost for the first year of operation is $6,000 (for condensation handling/repair, if necessary).

VAPOR EXTRACTION BLOWER MOTOR AND CONTROL SYSTEM

The vapor extraction blower motor and control system will be capable of removing a nominal 25,000 SCFM against a resistance of 3" Hg (approximately 400 HP). The Pilot Test indicates a steady-state soil resistance (after initial extraction development) of 2-1/2" Hg. The piping and manifold system will be designed for a maximum resistance of 1/2" Hg. The controls will consist of motor control and starter with automatic shut-off in the event of: 1) excessive condensation in the vacuum system; 2) high or low suction pressure levels; and 3) failure of the air pollution control systems.

The capital cost for this element is $100,000. The expected operating cost for the first year of operation is $200,000.

EXHAUST VAPOR TREATMENT SYSTEM

The exhaust vapor treatment system is expected to consist of granular activated carbon columns operating at a nominal capacity of 1000 SCFM. The carbon will remove between 200-300 lbs of VOC depending upon the compounds extracted. If two blowers are utilized, each will connect to 12 columns via an exhaust manifold. The 24 columns should provide enough capacity to adsorb all of the extracted organics. When the vapor extraction process is complete the adsorbed vapors will be thermally destroyed on the columns during on-site contaminant destruction/carbon regeneration.

The capital cost for this element is $50,000. The expected operating cost for the one year of operation is $300,000.

EXHAUST VAPOR STACK AND MONITORING SYSTEM

The exhaust vapor from the carbon columns will be manifolded to a stack with a nominal height of 20 ft. and a nominal diameter of 2.5 feet. The plenum connecting the carbon columns to the stack will have ports so that samples of exhaust vapor can be collected for subsequent analysis for volatile organic compounds.

The capital cost for this element is $30,000. The expected operating cost for the first year of operation is $60,000 (analytical).

COST SUMMARY

The attached tables summarize the capital and first year operating cost for each of the eight major cost elements. The expected total capital cost is estimated to be $325,000 and the expected total first year operating cost are estimated to be $604,000. These figures are preliminary in nature with an expected accuracy of +50/-25%. Please note that the total costs include a 20% allowance for engineering, 15% for project management during the first year of operation, and a 25% contingency.

EXPECTED DURATION OF THE VAPOR EXTRACTION SYSTEM OPERATION

The Pilot Test indicated an initial removal rate of 75 lb. of VOC per day, and a rate of 9.9 pounds per day at the end of the Pilot Test. The extraction rate appeared well-behaved and can be represented with a first order rate equation. The equation shown below provides a good fit to the HW-2 Pilot Test data:

$$R_t = R_o e^{-k_1 t}$$

Where R_t = rate at time t, lb/day/ft of trench
R_o = rate at time o, lb/day/ft
k_1 = rate constant, day $^{-1}$
t = time, day

TERRA VAC has estimated that essentially complete removal will occur within one year of operation. The exact duration of the operation will be determined by a risk based analysis of the residual contamination. It appears, therefore, that one year should represent a maximum duration of operation for the system, and has been selected to characterize the operational cost. In the event the system is operated for less than one year, the operational costs can be discounted in direct proportion to the actual duration.

cc: Norman Bernstein - ECC Steering Committee
Timothy Harker - ECC Steering Committee

TABLE 1

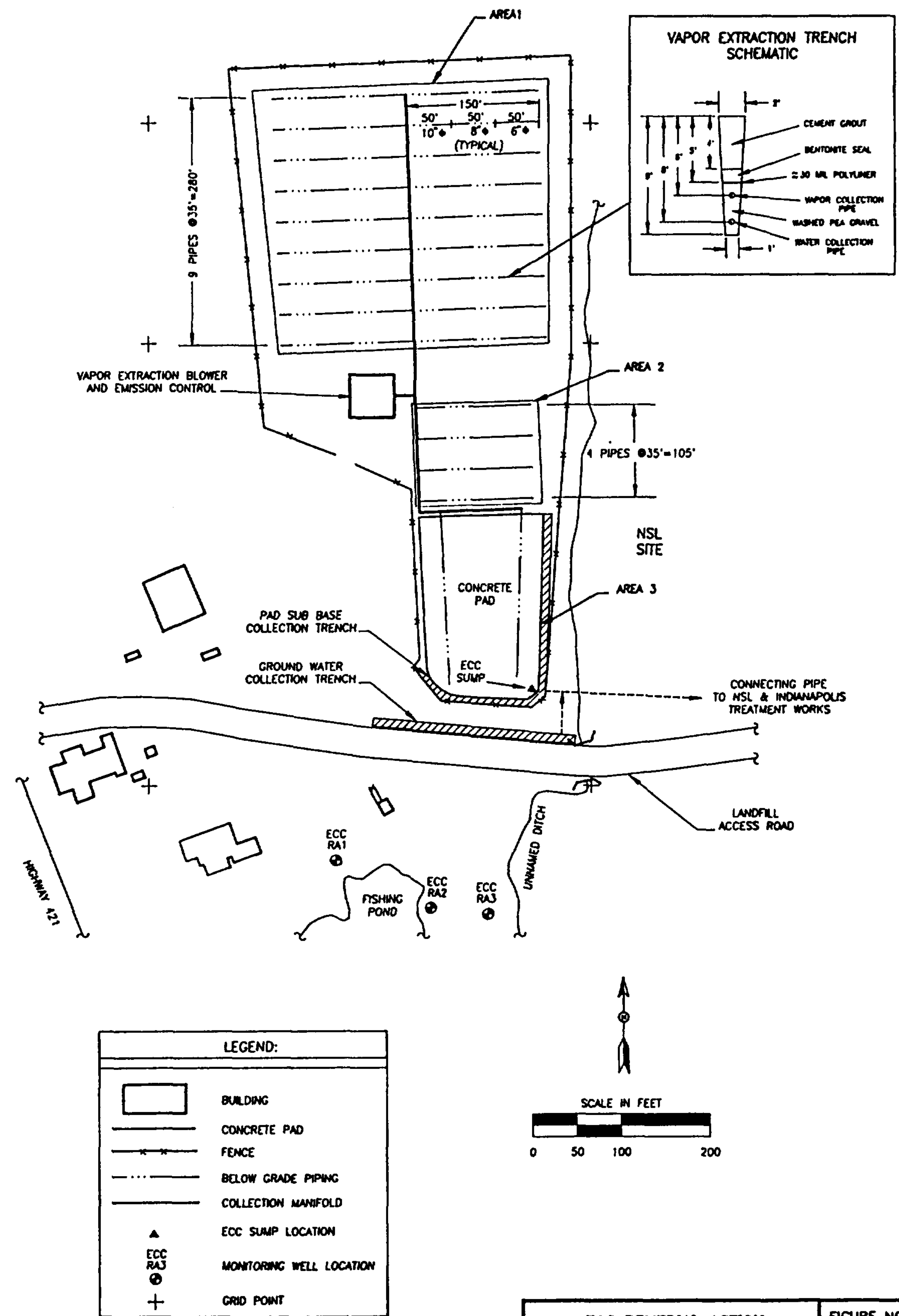
VAPOR EXTRACTION
PRELIMINARY COST ESTIMATE
(x $1000)

Cost Element	Capital		1 Year of Operation
1. Site Preparation	20		10
2. Trench Construction	0		10
3. Vapor Extraction Water Piping	70		6
4. Trench Backfill and Capping	40		12
5. Vapor Extraction Manifold System	15		6
6. Vapor Extraction Blower, Motor, Controls	100		200
7. Exhaust Vapor Preconcentration and Destruction	50		300
8. Exhaust Vapor Stack & Monitoring	30		60
	325		604
Engineering/Design	65	Proj.Mgmt.	90
Contingency	98	Contingency	174
	488		868

TABLE 2

VAPOR EXTRACTION
PRELIMINARY COST BASIS

Cost Element	Capital	Operation
1. Site Preparation	Lump Sum	Lump Sum
2. Trench Construction	0	2000 cu.yd at $5/cu.yd
3. Vapor Extraction Water Piping	3500 L.F. @ $20/L.F.	$500/mo. for 12 mo.
4. Trench Backfill and Capping	2000 cu.yd. @ $20/cu.yd.	$1000/mo. for 12 mo.
5. Vapor Extraction Manifold System	300 L.F. @ $50/L.F.	$500/mo. for 12 mo.
6. Vapor Extraction Blower, Motor, Controls	Lump Sum	$130,000 electricity @ $0.05 KWH $ 70,000 maintenance
7. Exhaust Vapor Preconcentration and Destruction	Lump Sum	5500 lbs. VOCs Carbon @ $3/lb @ 0.1 capacity Subsequent thermal destruction
8. Exhaust Vapor Stack & Monitoring	Lump Sum	$5000/mo. for 12 mo.



NOTE: EXISTING SITE STRUCTURES ARE NOT SHOWN FOR THE SAKE OF CLARITY.

ECC REMEDIAL ACTION: VAPOR EXTRACTION SYSTEM	FIGURE NO. 1
ERM ERM-North Central, Inc.	mo

APPENDIX B

ECC REMEDIAL ACTION PLAN
ESTIMATION OF WATER VOLUMES COLLECTED IN THE GROUND WATER INTERCEPTION TRENCH

APPENDIX B

ECC REMEDIAL ACTION PLAN
ESTIMATION OF WATER VOLUMES COLLECTED IN THE GROUND WATER INTERCEPTION TRENCH

Following the procedure in Appendix B of the FS:

$$Q_t = Q_r + Q_i + Q_{rec}$$

where:

Q_t = total water flow to the trench, gpm

Q_r = regional ground water flow to the trench, gpm

Q_i = flow induced due to the presence of the trench, gpm

Q_{rec} = recharge flow, due to precipitation and upward recharge from the sand and gravel unit, gpm

$$Q_r = K_r \cdot A_r \cdot i_r$$

where:

K_r = permeability of till = 10^{-5} cm/s = 0.212 gal/d.ft^2 (section 5 of RI)

d = depth of trench, assume 10 ft

A_r = area of trench in the direction of ground water flow, ft^2 = L x d

L = length of trench, 330 ft

i_r = regional gradient = 0.05 ft/ft south of the site (Appendix B of FS)

$$Q_i = K_i \cdot i_I \cdot A_i$$

where:

K_i = permeability of till = 10^{-5} cm/s - 0.212 gal/d.ft^2 (Section 5 of RI)

i_i = gradient induced due to drain - h/l

h = height of water table above the drain centers = 1/2 maximum depth = 5 ft

l = z/2 = 20 ft

z = zone of influence of trench in the perpendicular direction, 40 ft

A_i = area of induced flow = L x h

$$Q_{rec} = (W_p + W_v)\ A_{rec}$$

where:

W_p = recharge due to precipitation, assumed to be 7.8 in/yr = 0.013 gal/d.ft^2 (Appendix B of FS)

W_v = recharge due to upward movement from the sand and gravel unit = k_v x i_v

k_v = vertical permeability of till assumed to be 10^{-5} cm/s = 0.212 gal/d.ft^2

i_v = vertical gradient = 0.25 ft/ft = 3 ft difference in head over 12 ft of thickness of shallow saturated zone (Appendix B of FS)

A_{rec} = recharge area, ft^2 - L x Z

For the trench to be installed at ECC =

Q_r = 0.212 gal/d.ft2 x 330 ft x 10 ft x 0.05 ft/ft x 1 d/1440 min
= 0.03 gpm

Q_i = 0.212 gal/d.ft^2 x 330 ft x 5 ft x 0.25 ft/ft x 1 d/1440 min
= 0.06 gpm

Q_{rec} = 0.013 gal/d.ft^2 x 330 ft x 40 ft x 1 d/1440 min + 0.212 gal/d.ft^2 x 330 ft x 40 ft x 0.25 ft/ft x 1 d/1440 min
= 0.61 gpm

Q_t = 0.03 + 0.06 + 0.61 = 0.70 gpm

APPENDIX B

DETERMINATION OF END POINT FOR VAPOR EXTRACTION

explain this whole Appendix

APPENDIX B

DETERMINATION OF END POINT FOR VAPOR EXTRACTION

The procedure consists of: (1) calculating the remaining soil concentration using the vapor concentrations; and (2) evaluating whether the concentrations of VOCs in soils are above acceptable levels by using the analysis results from water samples collected from individual trenches. An example is shown below.

1. <u>Concentrations in Soils Based on Vapor Concentration</u>

The concentration of VOCs in the extracted vapors can be related to the concentration in the soil through Henry's Law and the soil-water partition coefficient, on the basis that within the soil matrix, soil particles, moisture and soil vapor are in equilibrium.

The concentration of a VOC in soil moisture which is in equilibrium with soil particles can be estimated by the equation (Superfund Public Health Evaluation Manual, EPA, October, 1986):

$$C_w = k_d \cdot C_s$$

Where:

C_w = concentration of VOC in soil moisture, ug/l
k_d = soil-water partition coefficient, l/Kg
C_s = soil concentration of VOC, ug/Kg

The soil vapor VOC concentration in equilibrium with the soil moisture can be calculated using Henry's Law:

$$C_v = H \cdot C_w$$

Where:

C_v = soil vapor VOC concentration, mg/m^3
H = nondimensional Henry's Law constant

To account for the differences in soil concentrations, it will be assumed that, as vapor extraction proceeds, the VOC concentrations in the soils will follow the same distribution as currently present in the soil. To determine the acceptable average soil concentration, the following equation will be used:

$$C_{s,avg} = C_{s,acc} \cdot C_{s,50}/C_{s,95}$$ reference?

Where:

$C_{s,avg}$ = acceptable average soil concentration, ug/Kg
$C_{s,acc}$ = acceptable soil concentration, ug/Kg
$C_{s,50}$ = value which represents a 50% probability that the samples collected on-site had concentrations less than or equal to this value, ug/Kg
$C_{s,95}$ = value which represents a 95% probability that the samples collected on-site had concentrations less than or equal to this value, ug/Kg

The shut-off vapor concentration will be calculated as:

$$C_{v,off} = H \cdot K_d \cdot C_{s,acc} \cdot C_{s,50}/C_{s,95}$$ reference

The vapor extraction system will be operated until vapor concentrations are reduced to the shut-off levels. For example, the shut-off vapor concentration for TCE is 0.0363 mg/m^3, calculated using the following data:

H	$= 0.378$	Superfund Public Health Eval. Manual, October, 1986
k_d	$= 0.24$	Table 5-3 of ECC RI
$C_{s,50}$	$= 15$ ug/Kg	Table B-1 attached
$C_{s,95}$	$= 150{,}000$ ug/Kg	Table B-1 attached
$C_{s,acc}$	$= 4000$ ug/Kg	Appendix C-1 of ECC RI

If a TCE vapor concentration of 0.1 mg/m^3 is detected, the corresponding soil concentration would be:

$$C_s = C_v \cdot C_{s,95} / (C_{s,50} \cdot H \cdot k_d)$$

$$C_s = (0.1\ mg/m^3) \times (150{,}000\ ug/Kg)/((15\ ug/KG) \times (0.378) \times (0.24))$$

$$= 11{,}020\ ug/Kg$$

2. Concentration in Soils Based on Water Concentrations

It is assumed that a sample of water from one of the sampling ports in the water manifold of the vapor extraction system had a TCE concentration of 1200 ug/l.

how do they ~~equation~~ this?

The trench is 150 feet long. Assuming that only 10 feet of trench receive water from soils with TCE concentrations higher than the acceptable 4000 ug/Kg level, the actual concentration of TCE in the water is (1200 ug/l) x (150 ft/10 ft) = 18,000 ug/l. This water can be assumed to be in equilibrium with the soil concentrations, due to the slow ground water travel velocity in the ~~fill.~~ till.

where did they get this?

From the ECC RI, Table 5-3, the soil-water partition coefficient is $k_d = 0.24$. The soil concentration in equilibrium with the collected water is:

not in RI

$$C_s = C_w\ k_d$$

$$= (18{,}000\ ug/l) \times (0.24) = 4320\ ug/Kg$$

780.7 (from table in RO)
x 150/10
1210.5 ug/l
x .24
290.52 ug/l in soil

in water

Therefore, the TCE soil concentration in this area is above acceptable levels, and vapor extraction operations must be continued.

only works
assuming no dilution
w/ atmospheric air)
assume no dilution & STP
- only good under
laboratory conditions -
needs to be proven in field.
The necessity for soil
samples still exists
for verification

TABLE B-1

DISTRIBUTION OF TCE SAMPLING RESULTS

Location	Depth	Concentration (ug/Kg)	Rank	Probability of Occurrence (%)
TP-1	1-1.5	ND	1	2.78
TP-2	1-1.5	ND	2	5.56
TP-5	2-3	ND	3	8.33
TP-6	2-3	ND	4	11.11
TP-11	1-3	ND	5	13.89
TP-1	4-5	ND	6	16.67
TP-4	2.5-3.5	ND	7	19.44
TP-6	4-5	ND	8	22.22
TP-11	3-5	ND	9	25.00
SB-04	2-3.5	ND	10	27.78
SBO104	5.5-7	ND	11	30.56
SBO204	5.5-7	ND	12	33.33
SBO403	5-6.5	ND	13	36.11
SBO805	7-8.5	3J	14	38.89
TP-10	3-5	6	15	41.67
TP-9	3-5	13	16	44.44
TP-8	1-2.5	14	17	47.22
TP-10	1-3	15	18	50.00
SB-08	2.5-4	16J	19	52.78
SB-01	2.5-4	39	20	55.56
SBO904	5.7-7	76	21	58.33
TP-12	3-5	86	22	61.11
TP-4	1-2	280B	23	63.89
SB-03	2.5-4	340	24	66.67
TP-12	1-3	410	25	69.44
TP-5	1-2	580	26	72.22
SB-09	2.5-4	640	27	75.00
TP-7	2.5-4	1800	28	77.78
TP-3	1-1.5	3400B	29	80.56
TP-7	1-2.5	6000	30	83.33
TP-8	2.5-4	66,000	31	86.11
SB-02	2.5-4	68,000	32	88.89
SB-06	2-3.5	110,000	33	91.67
TP-9	1-3	150,000	34	94.44
TP-6	1-2	4,800,000B	35	97.22

Probability of Occurrence = rank/(total number of samples +1)
ND: Not detected
B : Analyte has been found in the laboratory blank as well as in the sample. Indicates probable contamination.
J : Indicates an estimated value. When mass spectral data indicates the presence of a compound that meets the identification criteria and the result is less than the specified detection limit but greater than zero.

APPENDIX C

ESTIMATION OF WATER VOLUMES COLLECTED IN THE GROUND WATER INTERCEPTION TRENCH

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where:

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d = depth of trench, assume 10 ft

A_r = area of trench in the direction of ground water flow, ft^2 = L x d

L = length of trench, 330 ft

i_r = regional gradient = 0.05 ft/ft south of the site (Appendix B of FS)

$$Q_i = K_i \cdot i_I \cdot A_i$$

where:

K_i = permeability of till = 10^{-5} cm/s - 0.212 gal/d.ft^2 (Section 5 of RI)

i_i = gradient induced due to drain - h/l

h = height of water table above the drain centers = 1/2 maximum depth = 5 ft

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z = zone of influence of trench in the perpendicular direction, 40 ft

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= 0.61 gpm

Q_t = 0.03 + 0.06 + 0.61 = 0.70 gpm

ERM-North Central, Inc.
Environmental Resources Management

102 Wilmot Road • Suite 300 • Deerfield, Illinois 60015 ☎ (312) 940-7200

December 7, 1988

Karen Vendl
U.S. Environmental Protection Agency
Region V (5HE-12)
230 South Dearborn Street
Chicago, Illinois 60604

Re: ECC Remedial Action

Dear Ms. Vendl:

As instructed by the ECC Settlers Steering Committee, enclosed please find, for your review and comments, five (5) copies of the revised first two sections of Exhibit A to the Consent Decree for remediation of the Environmental Conservation and Chemical Corporation (ECC) site at Zionsville, Indiana.

Section 3, the complete design, will be provided in the near future and will include the following items:

- o Project Description;
- o Engineering Calculations;
- o Identification of Construction/Operation permits and requirements;
- o Detailed engineering specifications and drawings of:
  - Building and foundation
  - Electrical
  - Mechanical
  - Piping and instrumentation
  - Site plans with details
  - Demolition

- o Health and Safety Plan;
- o Quality Assurance Project Plan;
- o Operation and Maintenance Plan;
- o Final Construction Schedule

Please do not hesitate to call if you have any comments.

Very truly yours,

ERM-NORTH CENTRAL, INC.

Roy Ball/EFM

Roy O. Ball, Ph.D., P.E.
Principal

rms
enclosures

cc: D. Smith, Pratt & Lambert
J. Amber, Ford Motor Company
N. Bernstein, Jenner & Block
T. Harker, The Harker Firm
J. Kyle, Barnes & Thornburg
K. Johnson, Metal Working Lubricants

Baubat hid operation
financial
BF property
3rd area

Bev - ARARs for Soil - [illegible] [illegible] one goal,
2 consecutive semi-annual
↳ RCRA closure monitoring

1. Clean up levels

10:00 C.McK.

* where is point of compliance?

back calculate ARARs (stream criteria)
to get conc. in soil

clean closure - not affecting metals, PCBs
etc by SVE, do they have to do
more for clean closure

still don't know about gw collection
along E side (don't know ARARs
for sails, so don't know how long it
will operate)

Exhibit A

p2 second bullet eliminate "by rainwater";
" semi- helped some by SVE, metals not at all
3 - "uptake" - strange word - reword sentence
3 - treatment? not mentioned
3 - "will be"
- modify design, appropriate
fig 2-1
↳ wells should be nested
↳ dewater sump - need further details on SVE here
↳ surface drainage
↳ SVE <u>through</u> bldg foundation
↳ upgradient background well
↳ gw monitoring ports in SVE system
p5 - 35' separation should be 30'
5 - is "sump" the well, or the "area"; need to dewater this
5 - removal to <u>where?</u>
- <u>what concrete debris?</u>
- "interception system"
6 - sampling ports - each area of gw trenches
greater thickness
membranes
SCFM - define
nominals?
7 - will carbon handle greater 500 lbs

8- not just ~~foundation~~
Table 6-13 in RI, not an ARAR
"will result" - how does know